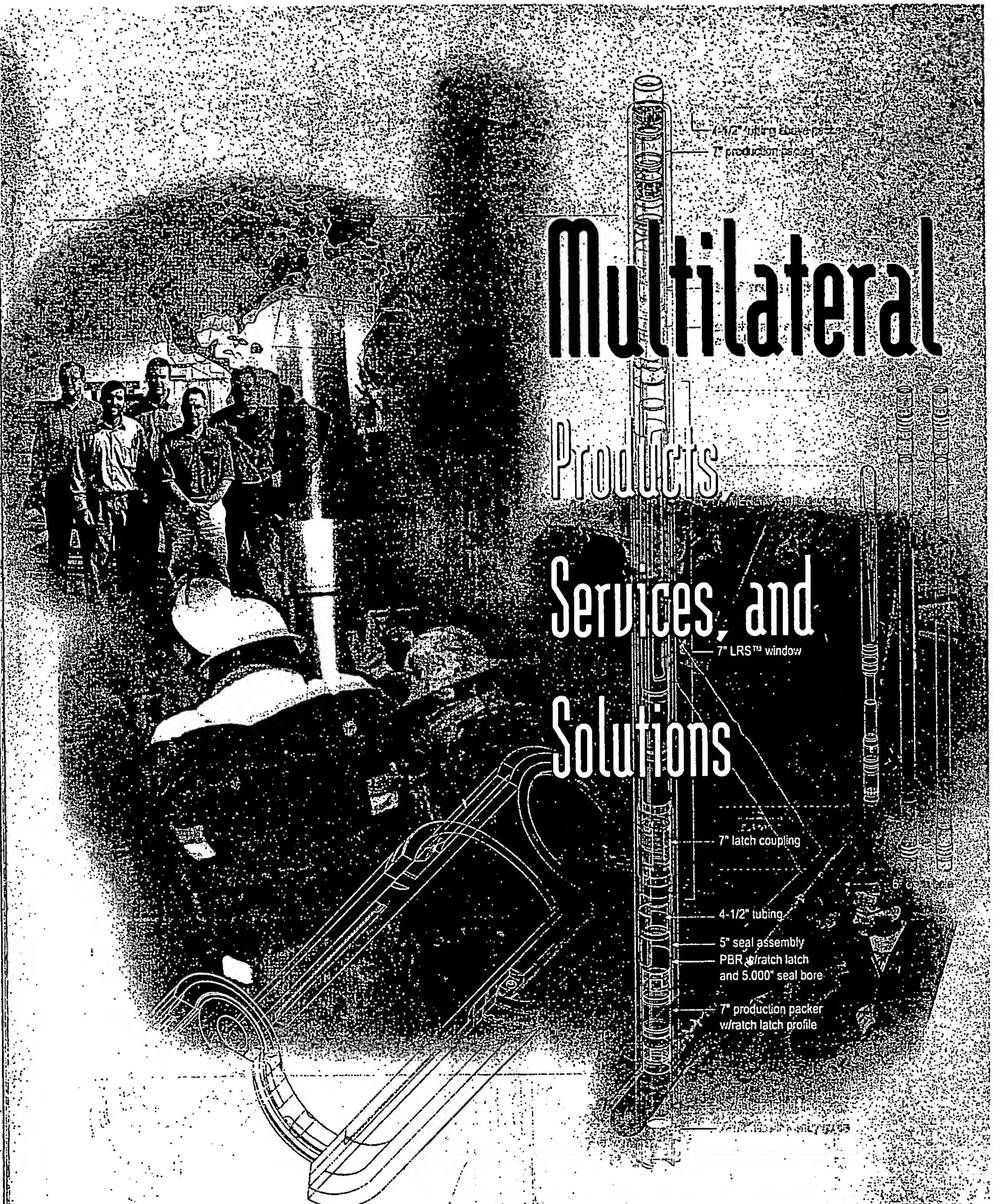
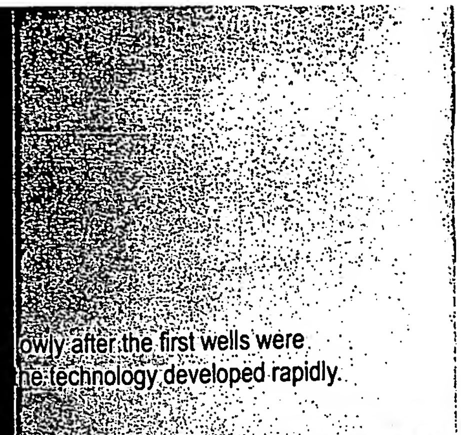
Multilateral Products, Services, and Solutions



sperry-sun
DRILLING SERVICES

70 Years



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SCS® system and
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stem installed by
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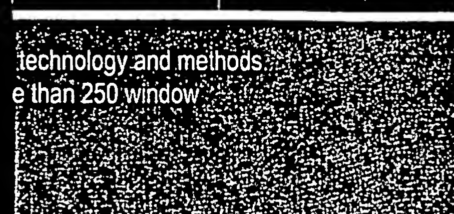
stem.

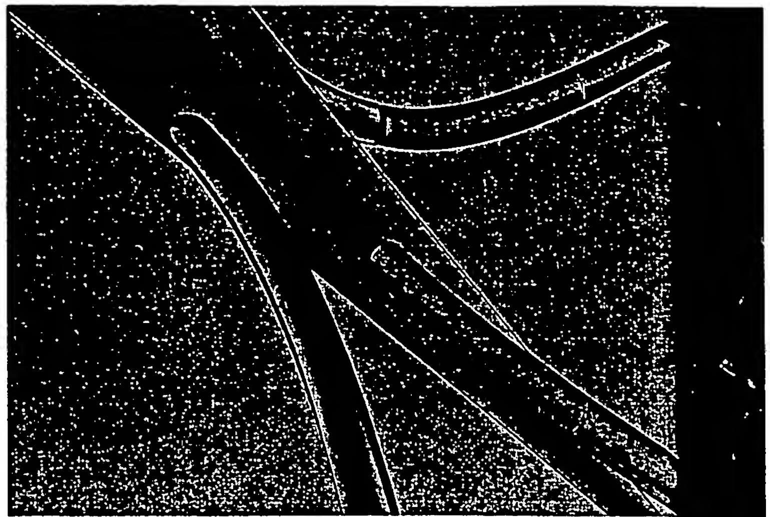
2000

January. 200th multilateral system installed by Sperry-Sun.

July. Sperry-Sun sets milestone in deepwater technology with installation of subsea TAML level 5 RMLS™/MSCS® injector well.



Introduction



Multilateral technology was developed to reduce overall well costs by using complex drainage architecture to increase the amount of reservoir exposure. The use of multilateral technology can be instrumental in cost savings throughout the life cycle of a well.

The purpose of the Multilateral Products, Services, and Solutions Catalog is to inform the various petroleum disciplines about the systems available and the planning necessary to make a multilateral well successful.

Multilateral systems enable multiple reservoirs, or areas within a reservoir to be produced simultaneously. Multilateral technology connects a lateral wellbore or a multitude of lateral wellbores to the main borehole at the multilateral junction. The junction can be designed in a new well application or created in an existing wellbore for a re-entry application. From the lateral bore, additional laterals, branches, or splays can be added to tie back additional reservoir targets. The main and lateral bore designs can be vertical, directional, or horizontal. Multilateral system selection is based on the individual requirements of the reservoir. Utilization of multilateral technology is a repeatable process that leads to decreased risk and lower costs.

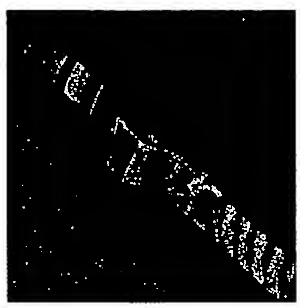
Instead of presenting only the multilateral systems themselves, we have included a description of the applications and well architecture in which multilateral systems are used. We consider the product from a project perspective from start to finish, just as you would. Our purpose is not only to inform you about the features of each system but also to assist you in the selection and design of the correct system for your particular application.

Sperry-Sun has installed more than 250 multilateral systems worldwide, leads the industry in research and development technologies, and offers the most experienced and talented people in the field, all of which ensure that you—the customer—are receiving the best service available.

We encourage you to refer to this catalog to assist you in future multilateral well planning. We hope this catalog brings value to you and your organization and as always, we invite your comments and suggestions.

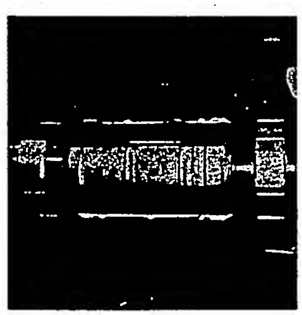
RDS™ Re-entry Drilling System milling machine

See pages 24, 25.

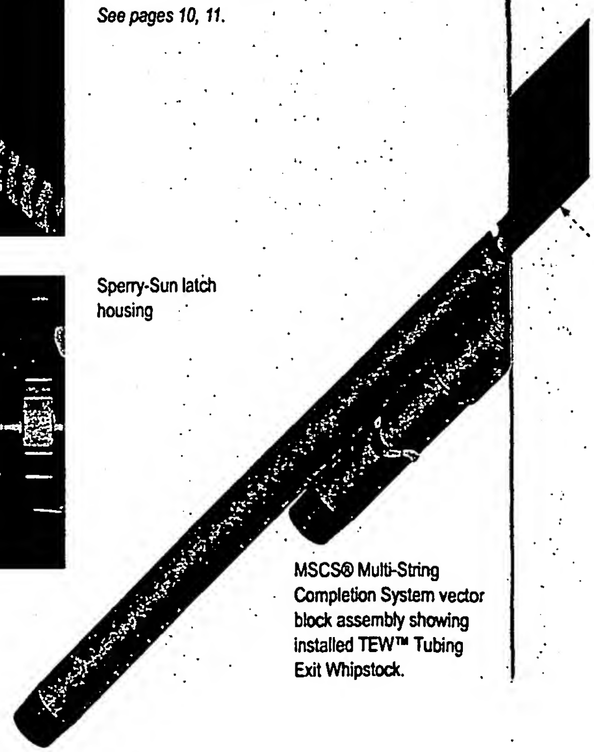


LTBS™ Lateral Tie-Back System gate closing tool

See pages 10, 11.

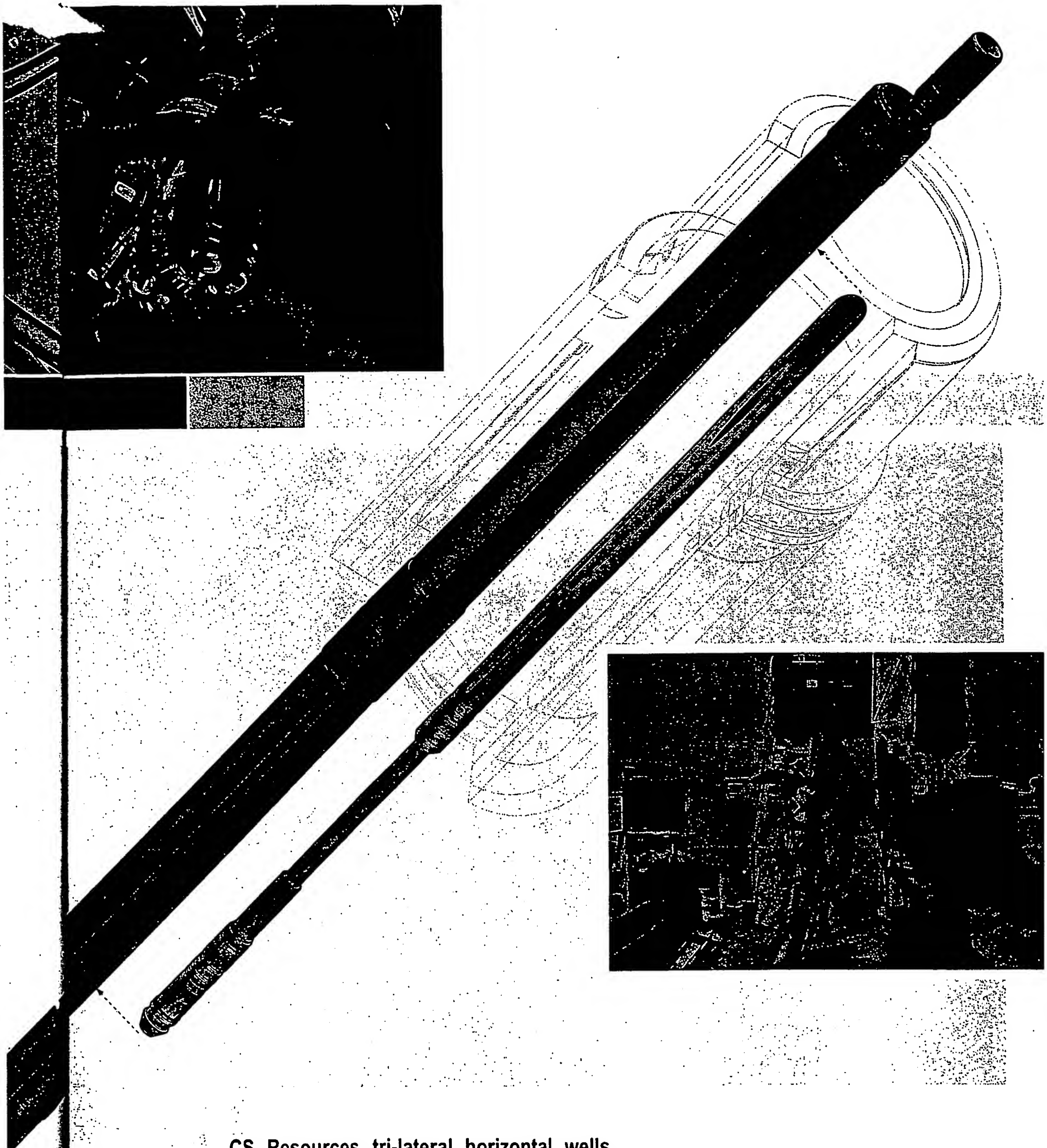


Sperry-Sun latch housing



MSCS® Multi-String Completion System vector block assembly showing installed TEW™ Tubing Exit Whipstock.

Sperry-Sun—"A World of Experience, a World of Opportunities"



CS Resources tri-lateral horizontal wells have increased productivity by up to three times and experienced a six-fold increase in recoverable reserves.

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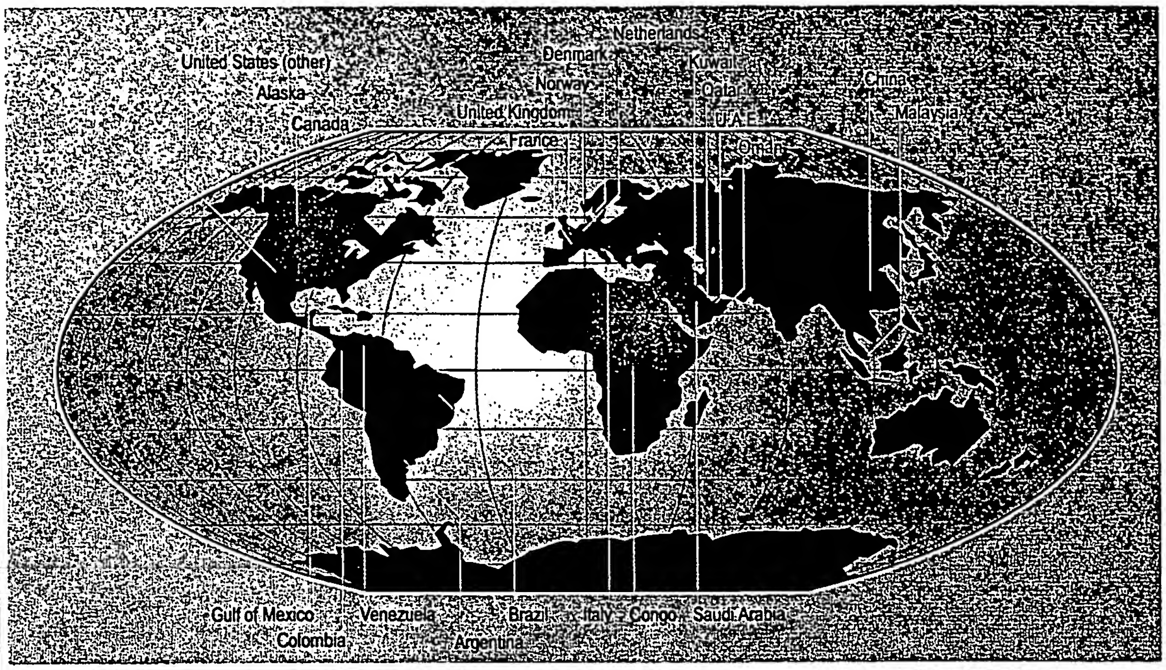
Tubing

Advantage

For 70 years, Sperry-Sun has delivered high-quality, safe, and efficient drilling and geological services. Sperry-Sun provides its customers with integrated service packages that include planning, executing, and analyzing programs for drilling and completion projects. Similarly, our commitment to partnering with customers is as old as the company itself. Indeed, Sperry-Sun was founded in 1930 in what might be considered one of the earliest operator/service provider partnerships. The company was born of the cooperative efforts of J. N. Pew, Jr., a member of Sun Oil Company's founding family, and Elmer Sperry, one of America's greatest inventors.

The Sperry-Sun/Halliburton Advantage

Sperry-Sun's Multilateral Experience



At the end of 1999, Sperry-Sun had drilled more than 600 multilateral wells encompassing nearly 900 lateral wellbores. Multilateral systems took off in the 1990s, and Sperry-Sun/Halliburton to date has installed more than 250 systems at level 2 or higher. Systems range from openhole sidetracks to hydraulic and mechanical isolation level 4 and 6 systems. Sperry-Sun/Halliburton installed the first commercial level 3 application and the first level 4 from a floater. We also lead the industry in total number of systems run to date.

As a division of Halliburton Energy Services (HES), Sperry-Sun has access to the leading resources and developments in Halliburton Company. As a business unit of Halliburton, HES brings an impressive array of products and technology to the customer, ranging from fully integrated solutions to best-in-class products and services for oil and gas exploration, development, and production. When you choose Sperry-Sun to drill and complete your multilateral well, you access the complete capabilities that only HES can provide.

Directional drilling and well planning. By providing experienced directional drilling and well planning services, Sperry-Sun ensures accurate, efficient wellbore placement.

Logging and perforating. HES offers cased hole and open hole wireline logging tools and magnetic resonance imaging technology from Numar.

Tools and testing. HES delivers accurate reservoir information through a full line of drillable, retrievable tools.

Integrated technology products. HES focuses on the rapid development and commercialization of HES technology solutions that maximize the performance of our clients' reservoirs.

Integrated solutions. By aligning the interests of the customer and Halliburton, the overall well, project, and field success can be greatly improved to the benefit of both parties.

Zonal isolation. As the world leader in cementing technology and services, HES reliably provides zonal isolation solutions.

Completion products. HES offers quality systems for virtually any type of completion and production operation.

Baroid drilling fluids. Baroid combines the most technically advanced drilling fluids and products with the most experienced, dedicated workforce in the industry.

Security DBS. Security DBS leads the world in roller cone rock bits, fixed-cutter bits, coring equipment and services, and downhole tools.

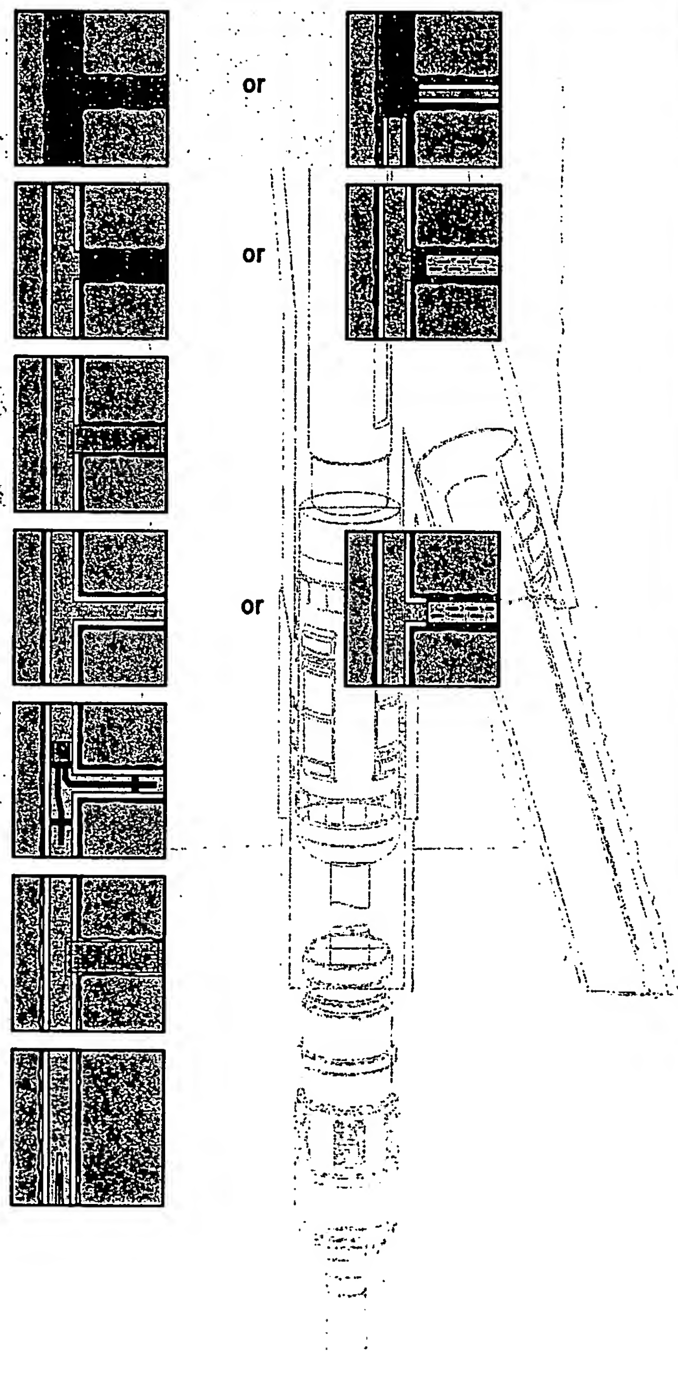
Production enhancement. HES services encompass the technologies and capabilities to optimize hydrocarbon reservoir performance, usually through pressure pumping.

Reservoir description. HES provides integrated reservoir description through a network of decision centers located in Aberdeen, Caracas, and Houston.

MWD and LWD. Sperry-Sun offers a complete range of reliable directional, formation evaluation, and drilling optimization sensors.

Classifications

Multilateral Classifications



1

Open/Unsupported Junction
Barefoot motherbore and lateral or slotted liner hung off in either bore

2

Motherbore Cased and Cemented*
Lateral Open
Lateral either barefoot or with slotted liner hung off in open hole

3

Motherbore Cased and Cemented*
Lateral Cased But Not Cemented
Lateral liner "anchored" to motherbore with a liner "hanger" but *not cemented*

4

Motherbore and Lateral Cased and Cemented*
Both bores cemented *at the junction*

5

Pressure Integrity at the Junction
(Cement is NOT acceptable)
Achieved with the completion

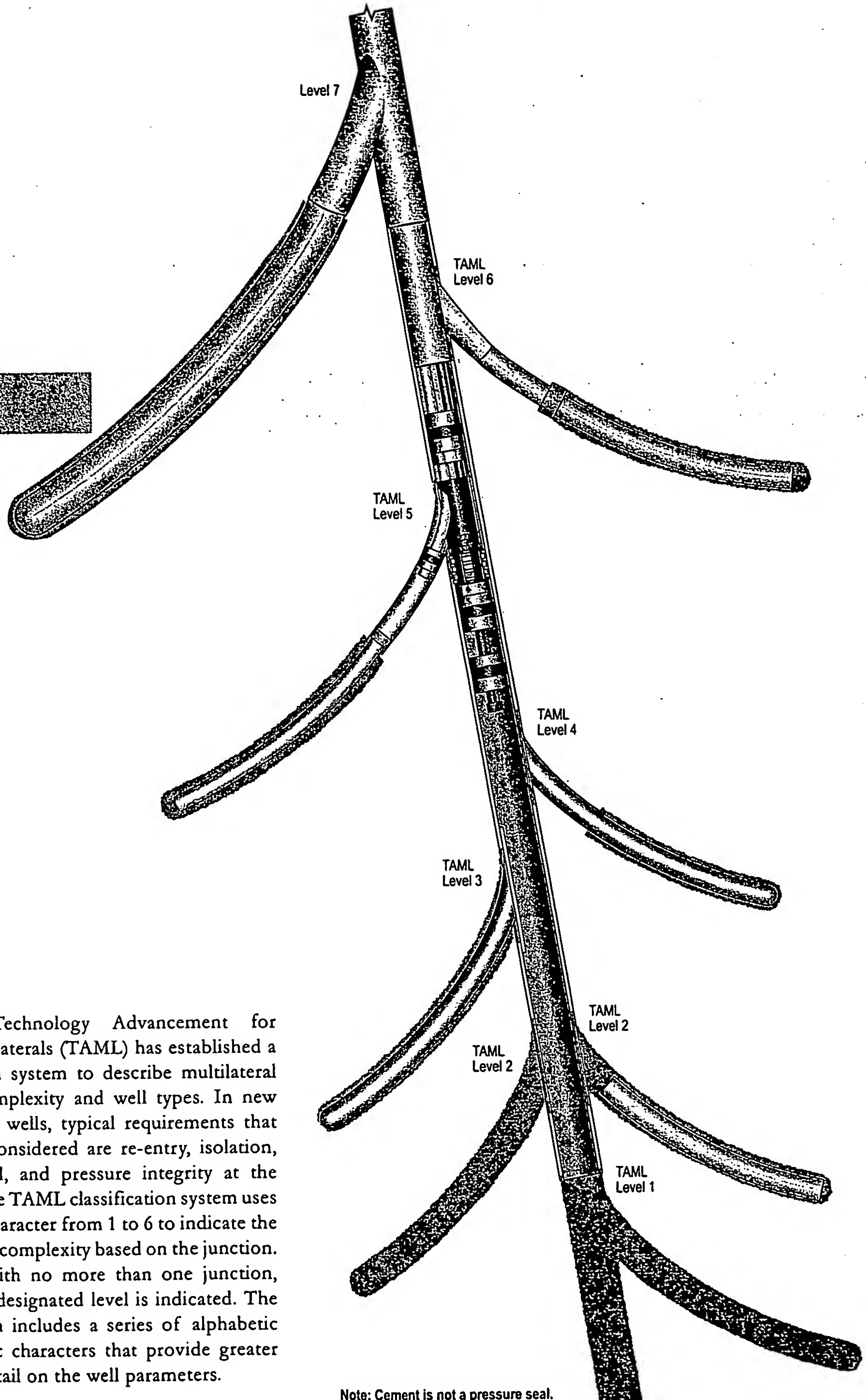
6

Pressure Integrity at the Junction
(Cement is NOT acceptable)
Achieved with the casing

6S

Downhole Splitter
Large main wellbore with two (smaller) lateral bores of equal size

**Cement or an equivalent chemical compound*



Note: Cement is not a pressure seal.

The Technology Advancement for Multilaterals (TAML) has established a classification system to describe multilateral junction complexity and well types. In new and existing wells, typical requirements that should be considered are re-entry, isolation, flow control, and pressure integrity at the junction. The TAML classification system uses a numeric character from 1 to 6 to indicate the level of well complexity based on the junction. In a well with no more than one junction, the highest designated level is indicated. The classification includes a series of alphabetic and numeric characters that provide greater technical detail on the well parameters.

Functionality Classification

Broken down into two sections, "Well Description" and "Junction Description," the functionality classification provides more technical detail of the well. Its primary use would be that of a "roadmap" in ascertaining critical requirements during the planning of a multilateral well or in describing the status of an existing well. In a well with more than one junction, each is described, from bottom to top.

WELL DESCRIPTION

New or existing well—issues such as choosing the method of casing exit and achieving pressure integrity at the junction must be resolved on a case by case basis.

Number of junctions—an important contributor to the well's complexity. The majority of wells to date have been dual laterals. As the technology develops, however, the average number of laterals per well will increase.

Well type—(producer—with or without artificial lift, injector, or multipurpose). The functionality requirements of a producer are different from an injector, particularly the level of pressure integrity required at the junction and the pressures exerted when the well is shut in.

Completion type—(single, dual, or concentric bore). This describes the completion above the production packer, which will have an impact on the type of equipment required at the junction.

JUNCTION DESCRIPTION

Connectivity—in dual laterals the indicator is the same as the one included in the complexity ranking. For wells with more than one junction, each junction has its own level indicator. If pressure integrity is required, that value is also included.

Accessibility—(no selective re-entry, re-entry by pulling completion, or through-tubing re-entry). Describes the level of re-entry access required.

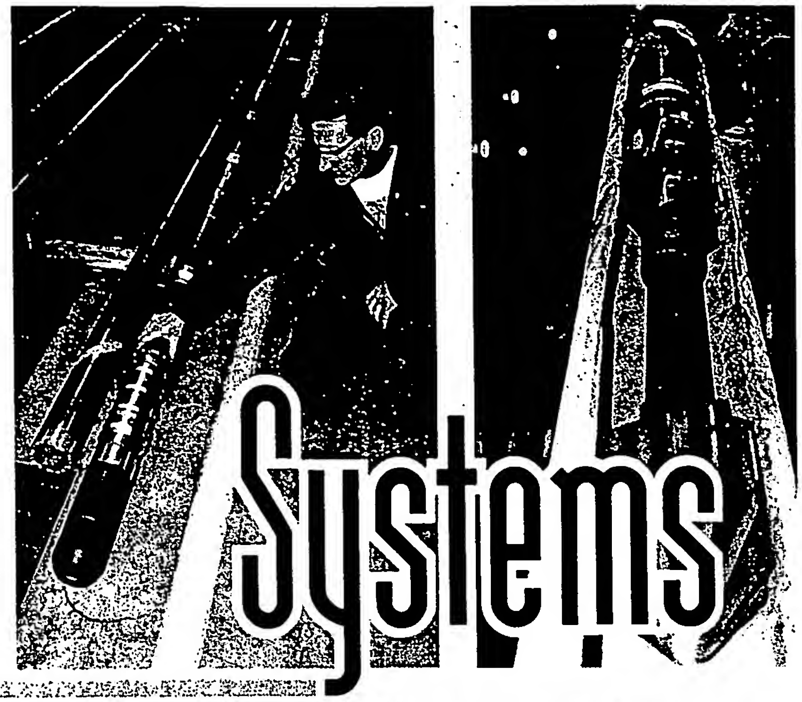
Flow control—(none, selective, separate, remote monitoring, or remote monitoring and control). Describes the degree of control over the production or injection fluid flow across the junction.

MULTILATERAL CLASSIFICATION EXAMPLE

Level 2; Ranking N-1-PN-S/2-TR-SEL

The name and numbers of the multilateral classification show the characteristics of the well. This multilateral system has a complexity ranking of level 2, which means that the main wellbore is cased and cemented with an open lateral that is either a barefoot or a slotted liner hung off the open hole. The N-1-PN-S/2-TR-SEL means that the well is new (N) with one junction (1) and a producer (P) with a natural lift (N) and single-bore completion (S). The junction is a motherbore cased and cemented (2) with through-tubing re-entry (TR) and selective production (SEL).

Thousands of level 1 and 2 junctions and several hundred level 4 junctions have been constructed. The most dynamic technology developments today occur in level 3 and 4 junction installations, with a growing trend in level 5 junctions being installed. Our newest multilateral addition is the PACE-6™ Pressure-Actuated Casing Exit system—our level 6 inflatable junction. Other new systems are also in development.



Sperry-Sun's multilateral junction and completion systems are divided into four main system categories as follows:

LatchMaster™ Pre-milled Window Systems—Used in new well applications, these junction systems incorporate a pre-milled window joint with a precise exit geometry. No downhole milling is necessary to create the lateral exit. Another key feature of these systems is the use of the Sperry-Sun latch coupling as the primary index. This allows precise depth control and azimuthal orientation to ensure guaranteed repeatable re-entry of the lateral. The LatchMaster™ series consists of the LTBS™ Lateral Tie-Back System, RMLS™ Retrievable Multilateral System, ITBS™ Isolated Tie-Back System, and PACE-6™ Pressure-Actuated Casing Exit System.

Sperry-Sun's Multilateral Junction and Completion Systems

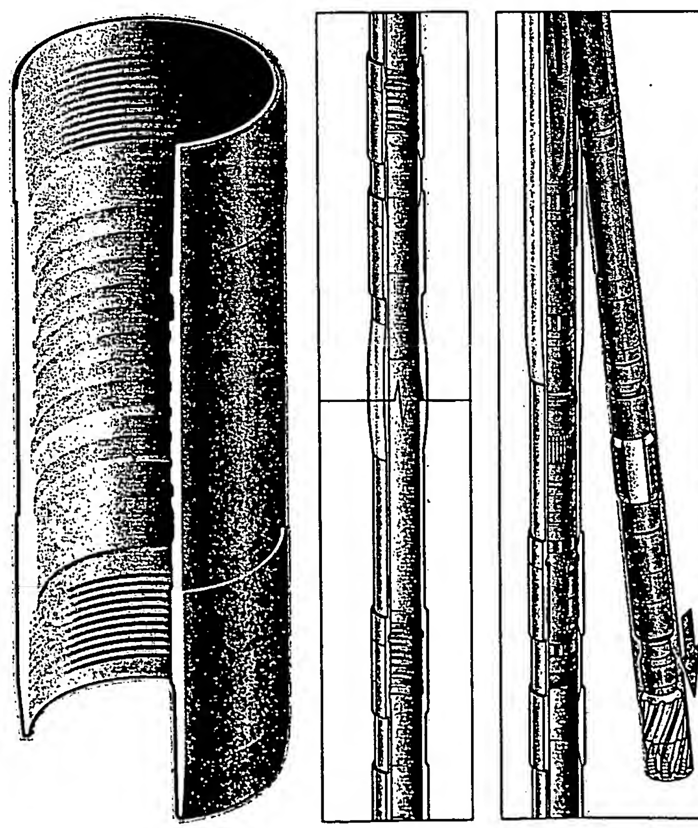
ExitMaster™ Milled Casing Exit Systems—Used in both new and re-entry well applications, these are junction systems in which all lateral exits for the multilateral windows are milled downhole. These systems may or may not utilize the Sperry-Sun latch coupling. The ExitMaster™ series consists of the 4501™ (Low-Side Perforation System), 4502™/4503™ Metal Mill-Through System, MERLIN™ Milled Exit Retrievable Multilateral System, and RDS™ Re-entry Drilling System.

BranchMaster™ Lateral Access Completion Systems—These completions systems are designed specifically for multilateral applications and allow re-entry into the lateral and lower mainbores. All allow isolation and flow control of the lateral and lower main zones and can be used in pre-milled or milled window junctions. These systems may or may not utilize the Sperry-Sun latch coupling. The BranchMaster™ series consists of the LRS™ Lateral Re-entry System, LRS-SL™ Self-Locating Lateral Re-entry System, MSCS® Multi-String Completion System, vector block, and TPI™ Through-Tubing Pressure Isolation Sleeve.

WorkMaster™ Workover Systems—Used in casing re-entry or through-tubing re-entry applications, these systems are designed specifically to allow re-entry into the lateral or lower mainbore to perform workover operations. These systems use a range of installation methods from drill pipe to coiled tubing or wireline. The WorkMaster™ series consists of the LRW™ Lateral Re-entry Whipstock, LRW-SL™ Self-Locating Lateral Re-entry Whipstock, TEW™ Tubing Exit Whipstock, and WREAL™ Wireline Re-entry Alignment System.

Latch Coupling

The latch coupling is the heart of Sperry-Sun's multilateral systems, providing full-bore inside diameter (ID) access to the mainbore and creating precise axial and azimuthal placement. Its pressure rating exceeds casing specifications. It allows accurate locators for re-entry of wells, repeatability at landing, and precisely oriented retrievable whipstocks.



LTBS™ Lateral Tie-Back System

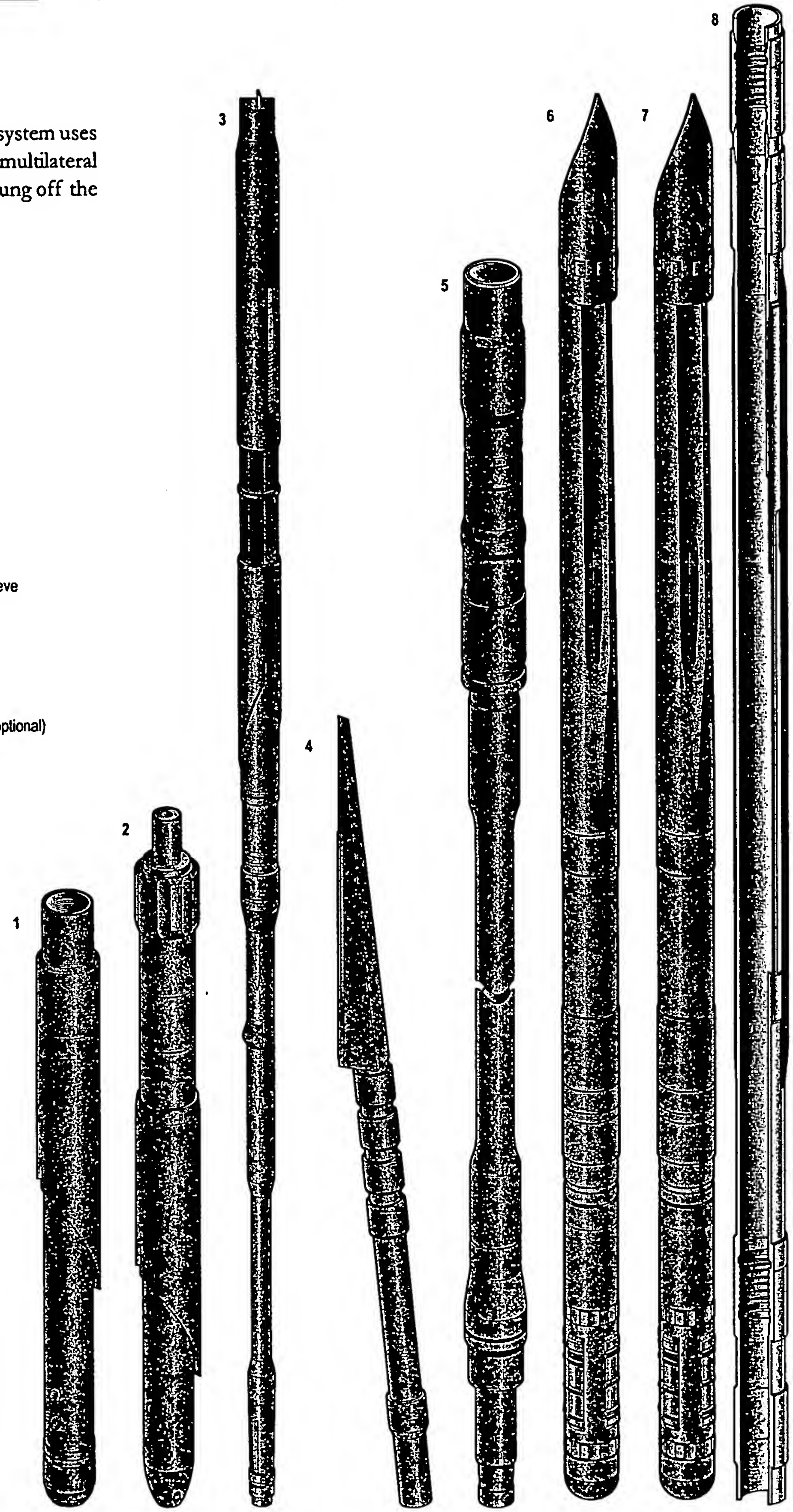
This multilateral junction construction system uses a pre-milled window for drilling new multilateral wells. The lateral liner is mechanically hung off the mainbore window.

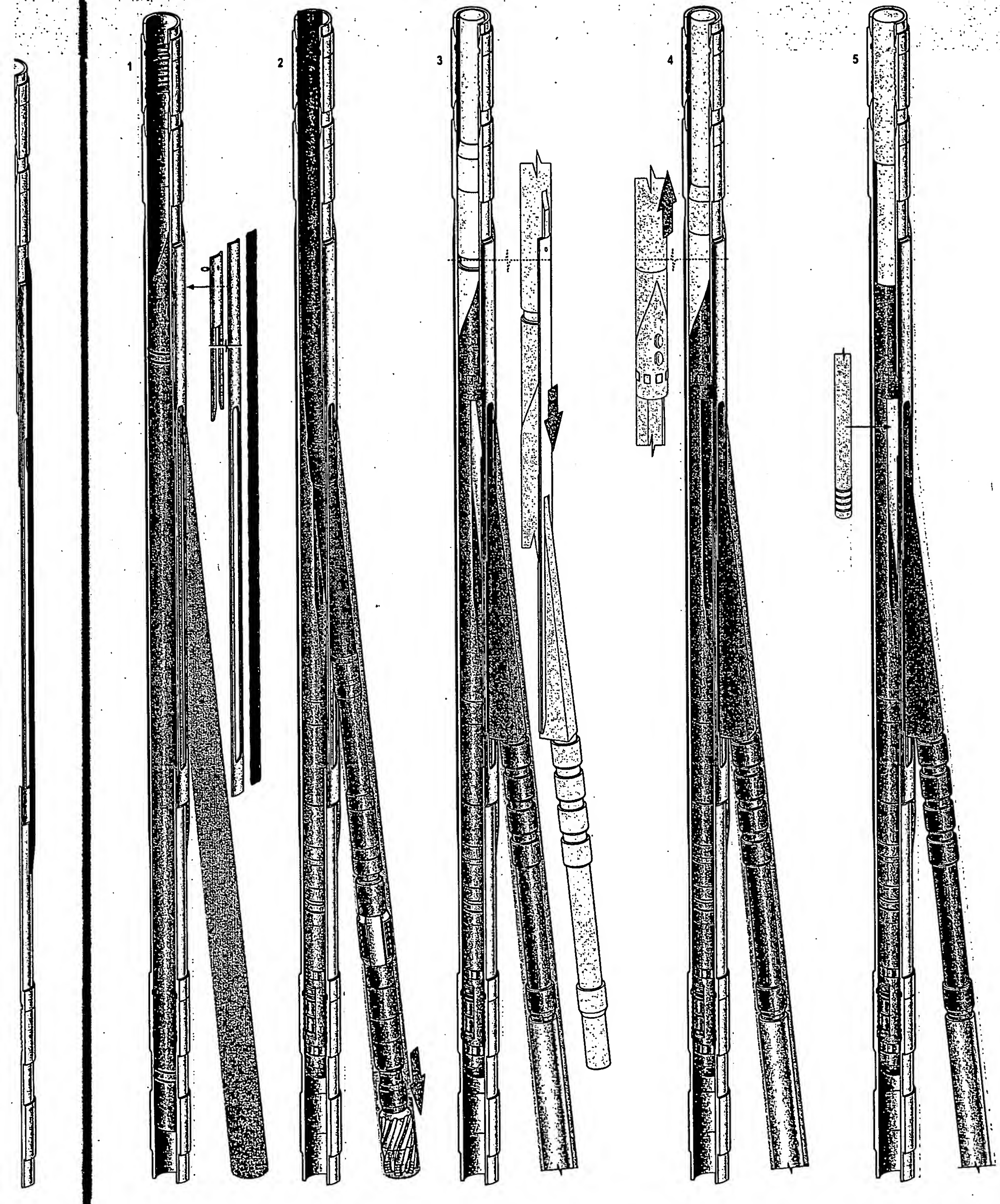
SYSTEM TOOLS: THIS PAGE

1. Hydraulic retrieving tool
2. Wireline orientation tool
3. Gate closing tool
4. Hanger assembly
5. Transition joint running tool
6. Drilling whipstock
7. Workover whipstock
8. Pre-milled LTBS™ window

OPERATIONAL SEQUENCE: NEXT PAGE

1. Install LTBS™ window with casing and cement. Retrieve internal sleeve.
2. Set drilling whipstock and drill lateral.
3. Install lateral liner, hang liner top, and close gate.
4. Retrieve drilling whipstock.
5. Install workover whipstock and cement lateral liner. (optional)

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RMLS™ Retrievable MultiLateral System

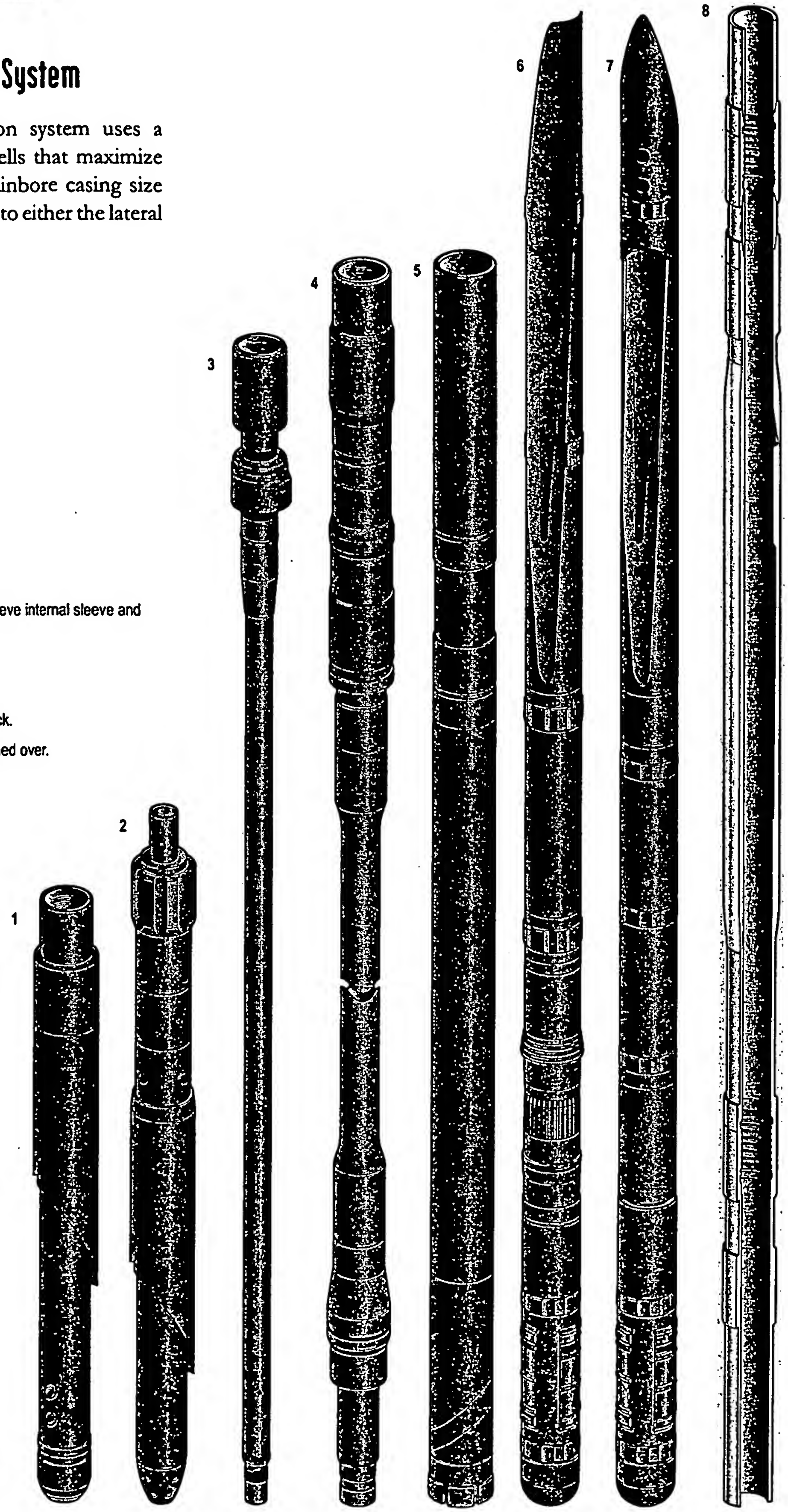
This multilateral junction construction system uses a pre-milled window for drilling new wells that maximize the lateral liner size relative to the mainbore casing size allowing full-bore access and re-entry into either the lateral or mainbore.

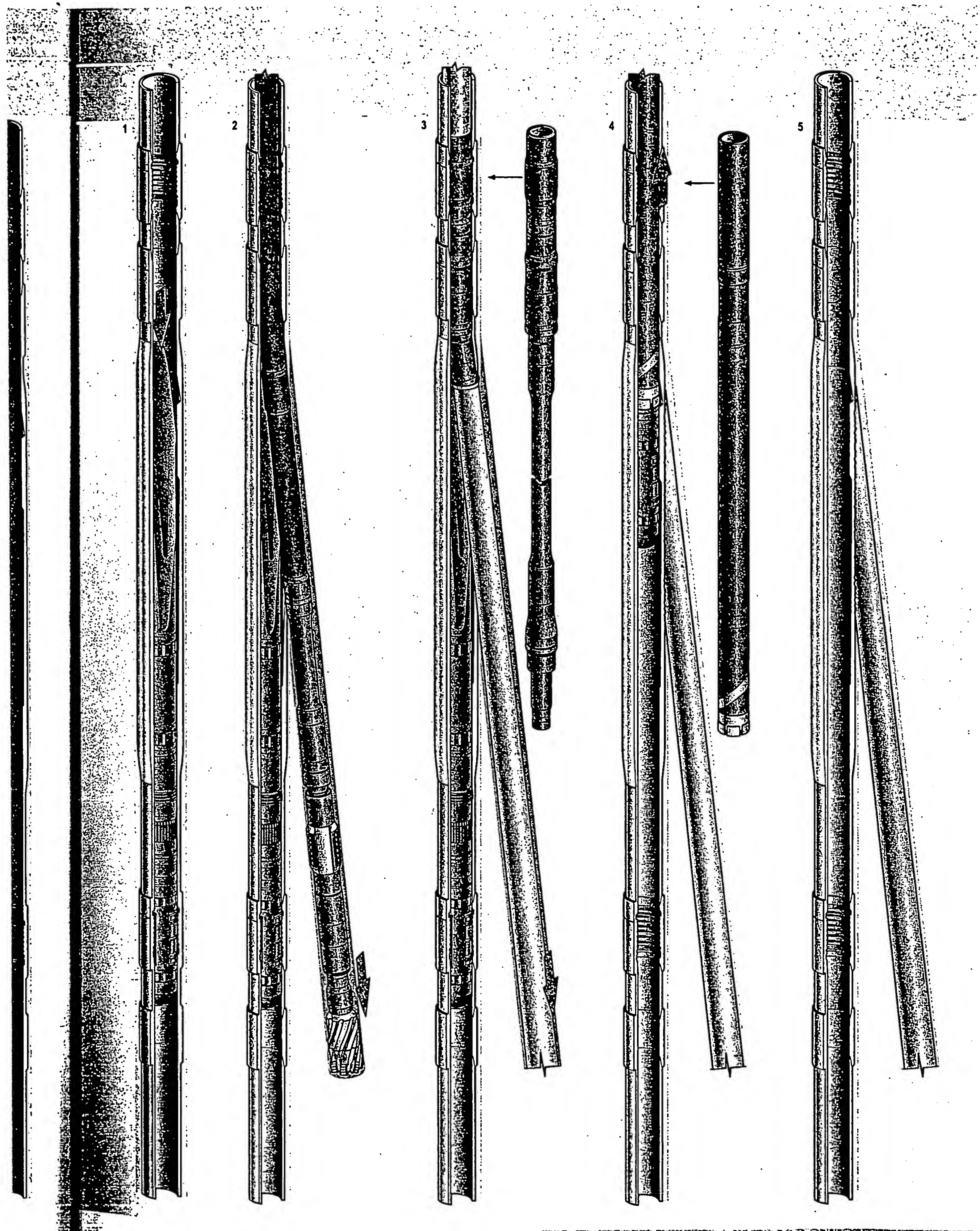
SYSTEM TOOLS: THIS PAGE

1. Hydraulic retrieving tool
2. Wireline orientation tool
3. Whipstock setting tool
4. Transition jt. running tool
5. Washover pipe with junkbasket
6. Washover whipstock
7. Workover whipstock
8. Pre-milled window

OPERATIONAL SEQUENCE: NEXT PAGE

1. Install RMLS™ window with casing and cement. Retrieve internal sleeve and install drilling whipstock.
2. Drill lateral.
3. Install lateral liner with transition joint and cement.
4. Washover lateral liner and retrieve washover whipstock.
5. Completed junction is shown with transition joint washed over.





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ITBS™ Isolated Tie-Back System

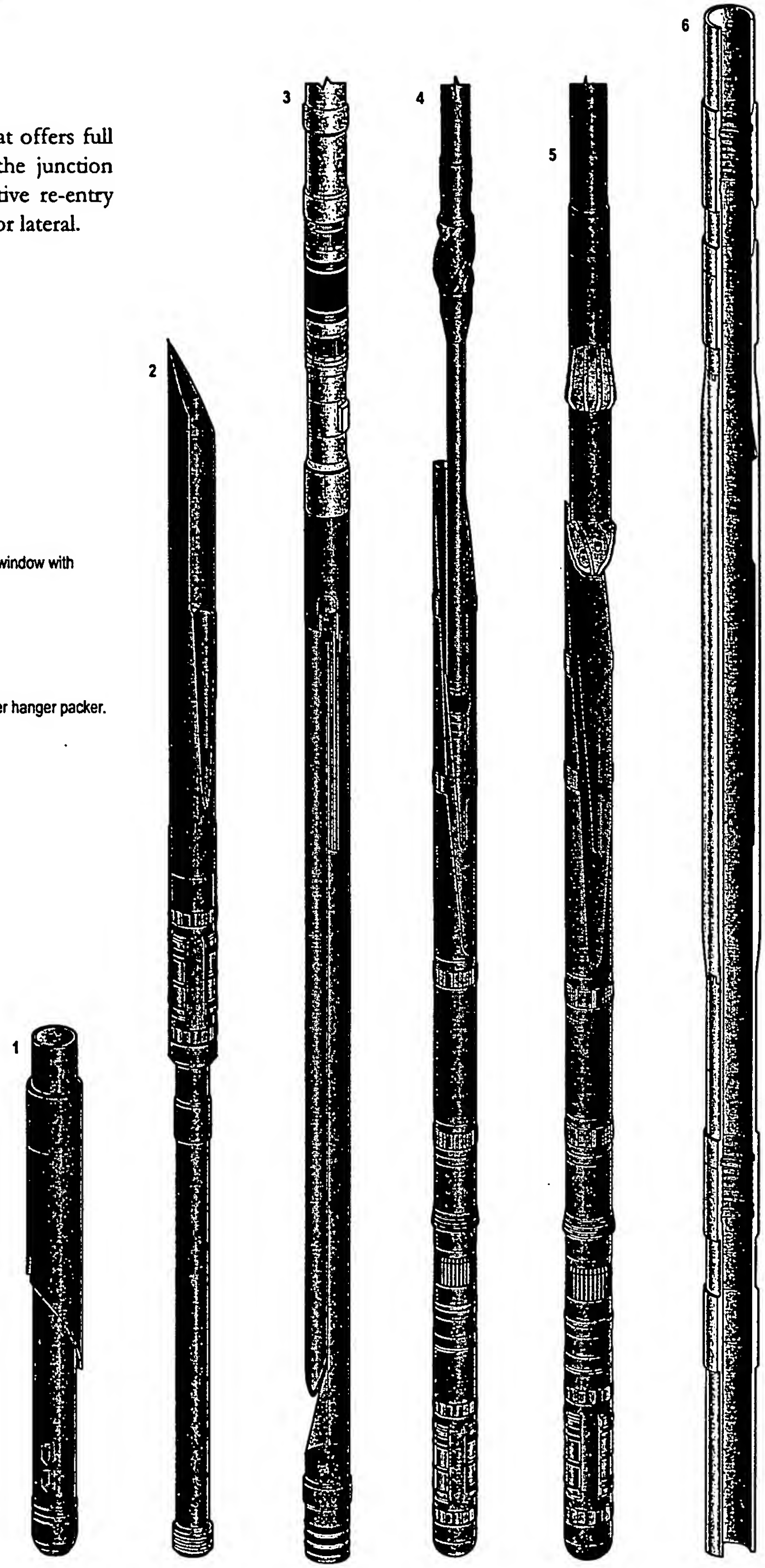
The ITBS™ is a debrisless metal system that offers full mechanical and hydraulic integrity across the junction without cement operations. It allows selective re-entry (without a rig) to either the lower mainbore or lateral.

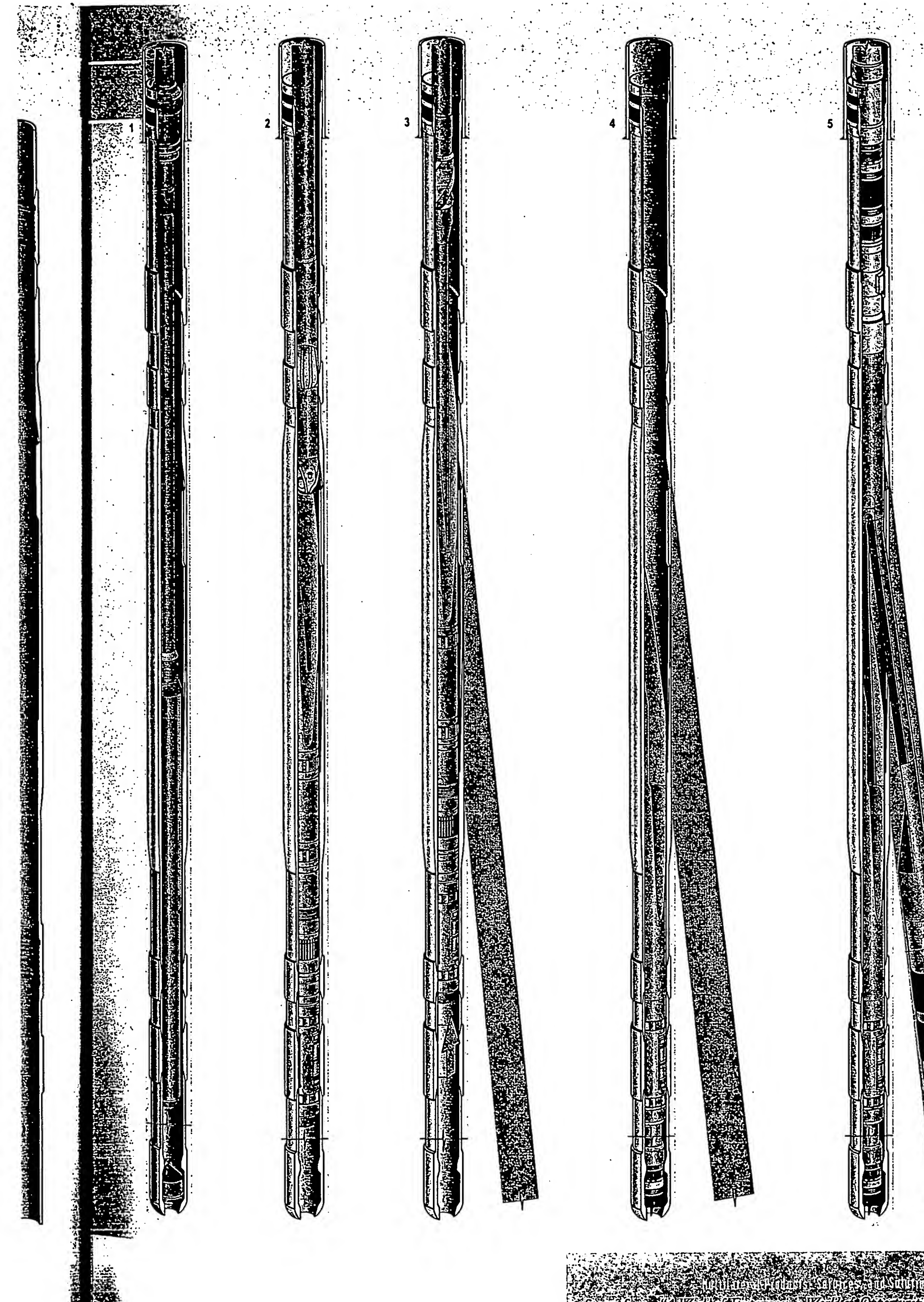
SYSTEM TOOLS: THIS PAGE

1. HMRT hydraulic mechanical retrieving tool
2. ITBS™ deflector
3. ITBS™ hanger assembly
4. Spear assembly and drilling whipstock
5. Drilling whipstock with bolted mills
6. Pre-milled ITBS™ window, aluminum jacket

OPERATIONAL SEQUENCE: NEXT PAGE

1. Install ITBS™ aluminum-wrapped window with casing. Orient window with internal string and cement.
2. Install drilling whipstock with bolted mills.
3. Drill out lateral and retrieve drilling whipstock.
4. Install ITBS™ deflector and set lower packer.
5. Run lateral liner and ITBS™ flexible D-shaped hanger. Set liner hanger packer.

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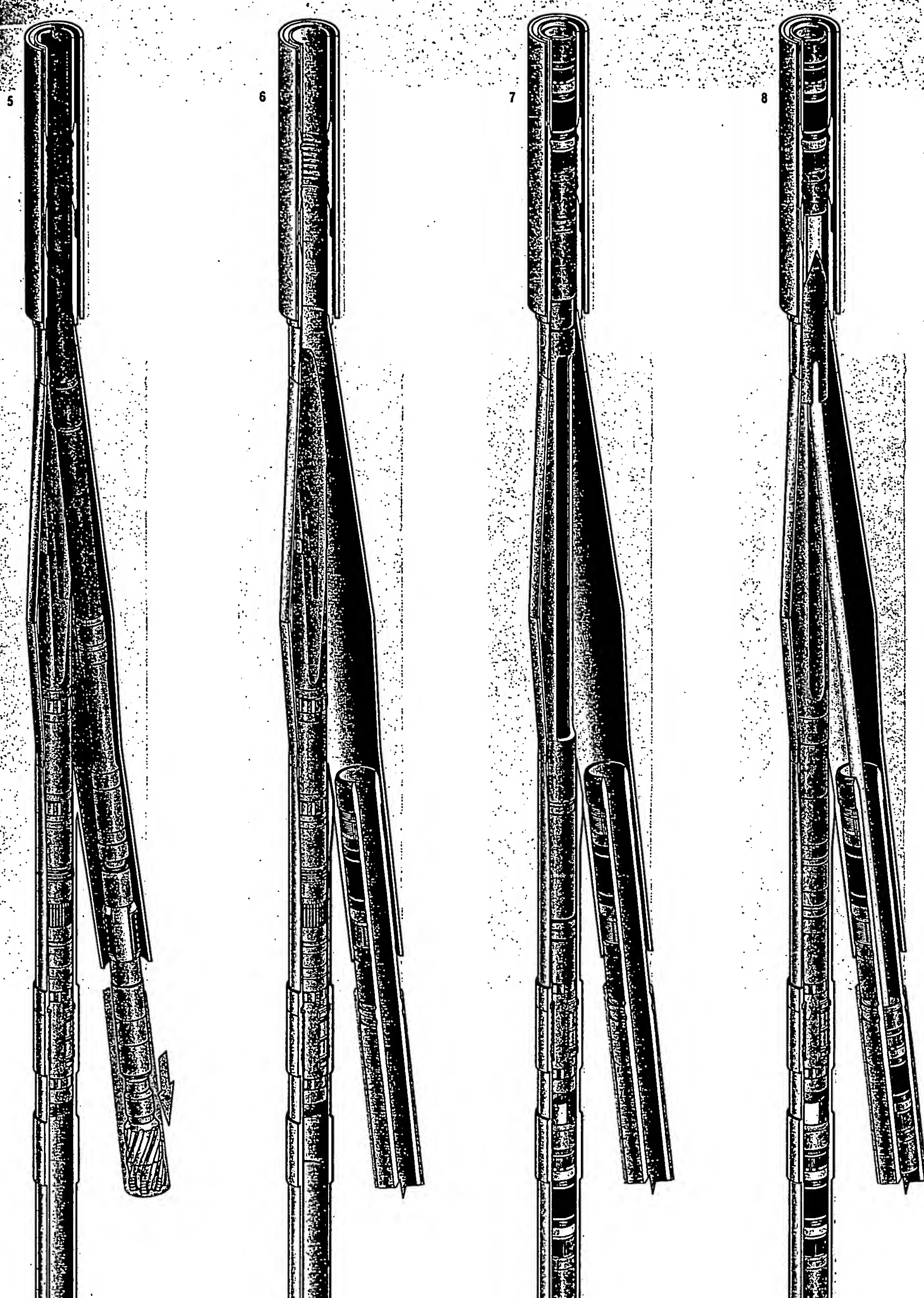
PACE-6™ Pressure-Actuated Casing Exit System

This high-pressure, deformable, multilateral construction system provides mechanical and hydraulic integrity at the lateral junction from the inflatable joint. It enables production from differentially pressured reservoirs.

OPERATIONAL SEQUENCE:

1. Set intermediate casing above the zone of interest.
2. Underream a hole section where the junction will be installed.
3. Install production casing with PACE-6™ inflatable window joint. Set within the underreamed hole section.
4. Apply surface pressure in order to deploy the inflatable metal junction. Cement the casing string.
5. Install drilling whipstock and drill the lateral.
6. Install the lateral liner and set liner hanger packer. Hydraulic isolation is achieved with conventional liner hanger packer.
7. Install LRS™ completion to allow commingled production. Mainbore and lateral access, isolation, and flow control can all be achieved without pulling the completion. (optional)
8. Install MSCS® completion, allowing independent access, isolation, and flow control. Potential for injector or producer. (optional)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4501™ Low-Side Perforation System

The 4501™ system is an advancement of conventional re-entry technology. It consists of milling a window and cementing a liner back into the mainbore. This multilateral junction construction system uses gravity-based, low-side perforation to re-establish hydraulic communication with the mainbore.

SYSTEM TOOLS: THIS PAGE

1. Hollow core whipstock and running tool
2. Starter mill
3. Window mill
4. Finishing mill

OPERATIONAL SEQUENCE: NEXT PAGE

1. Install 4501™ hollow core whipstock and set anchor packer.
2. Mill window using three-step milling operation, then drill lateral.
3. Install lateral liner and cement.
4. Run gravity bias perforating guns. Perforate top of hollow core whipstock to open hydraulic access to lower mainbore.
5. Isolate mainbore using straddle or isolate lateral using plug. (optional)

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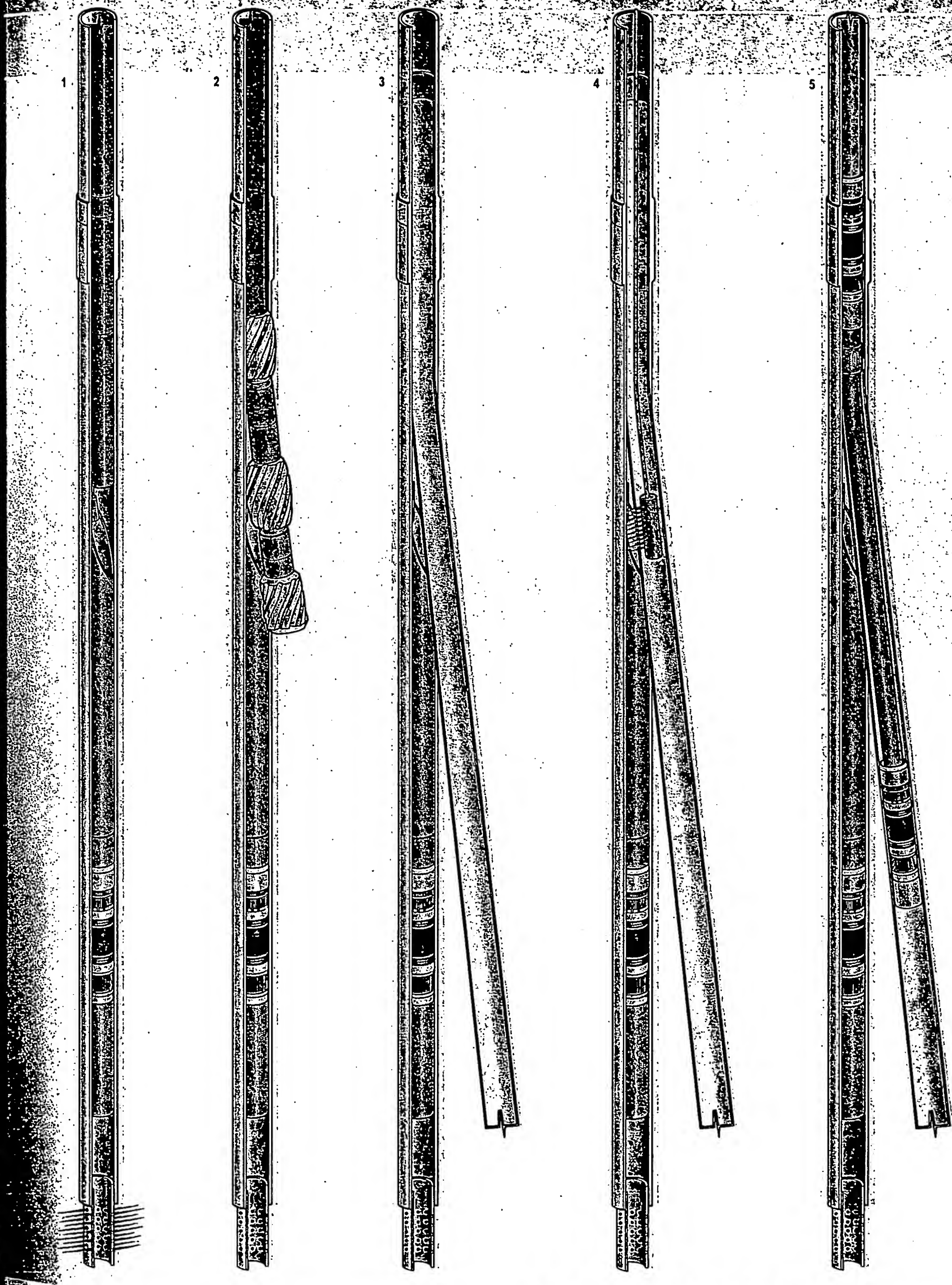

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4502™/4503™ Metal Mill-Through Systems

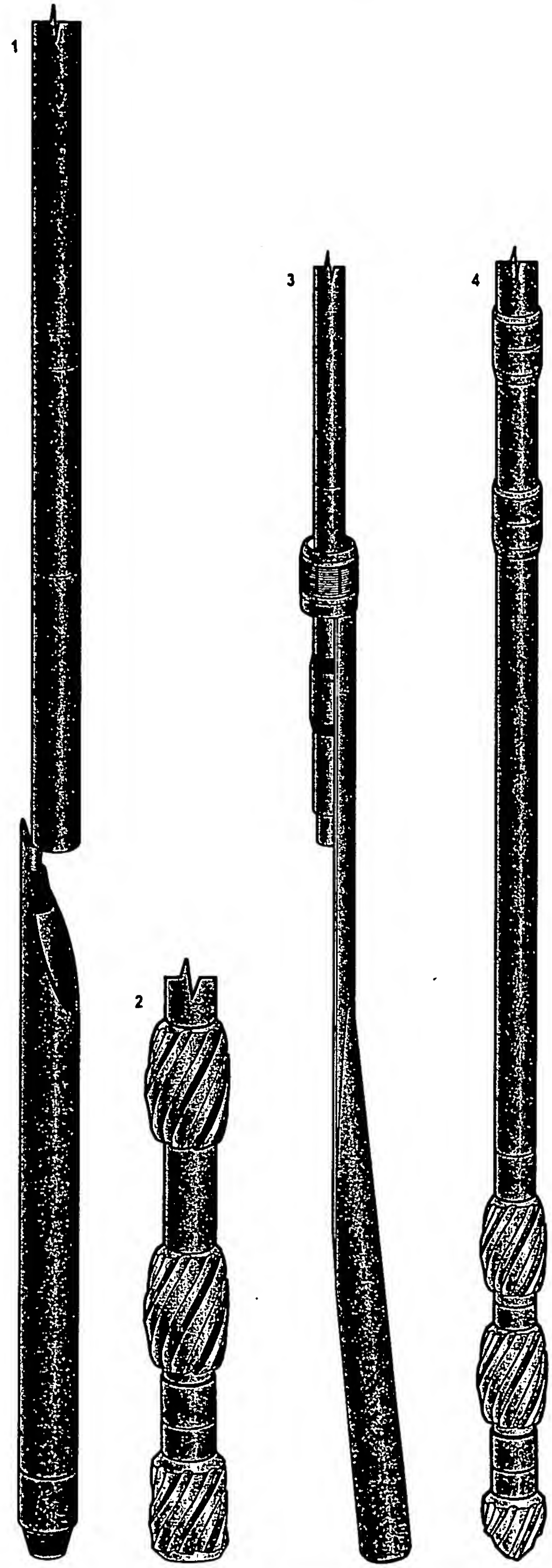
These systems do not require the retrieval of the drilling whipstock and provide for a strong mechanical junction with variable liner lap ability. The 4503™ system is specifically designed for subsea operations.

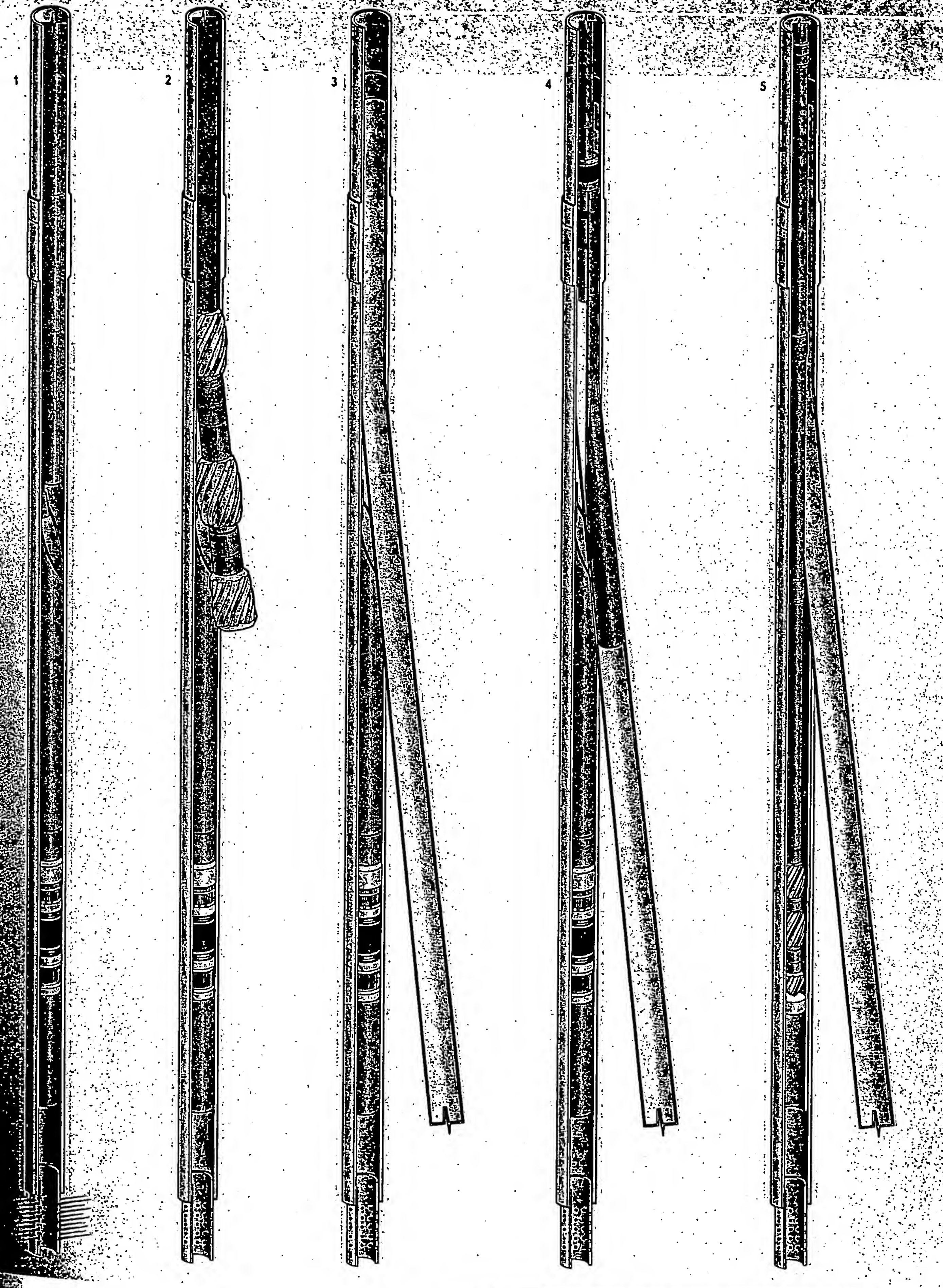
SYSTEM TOOLS: THIS PAGE, LEFT TO RIGHT

1. Hollow whipstock and running tool
2. Window mill
3. Mill guide and skirted mill
4. Reaming mills (watermelon mills and packer plug mill)

OPERATIONAL SEQUENCE, NEXT PAGE

1. Install 4502™/4503™ hollow core whipstock and set anchor packer.
2. Mill window using three-step milling operation, then drill lateral.
3. Install lateral liner and cement.
4. Install mill guide and skirted mill.
5. Run reaming mills to open mainbore ID.

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MERLIN™ Milled Exit Retrievable Multilateral System

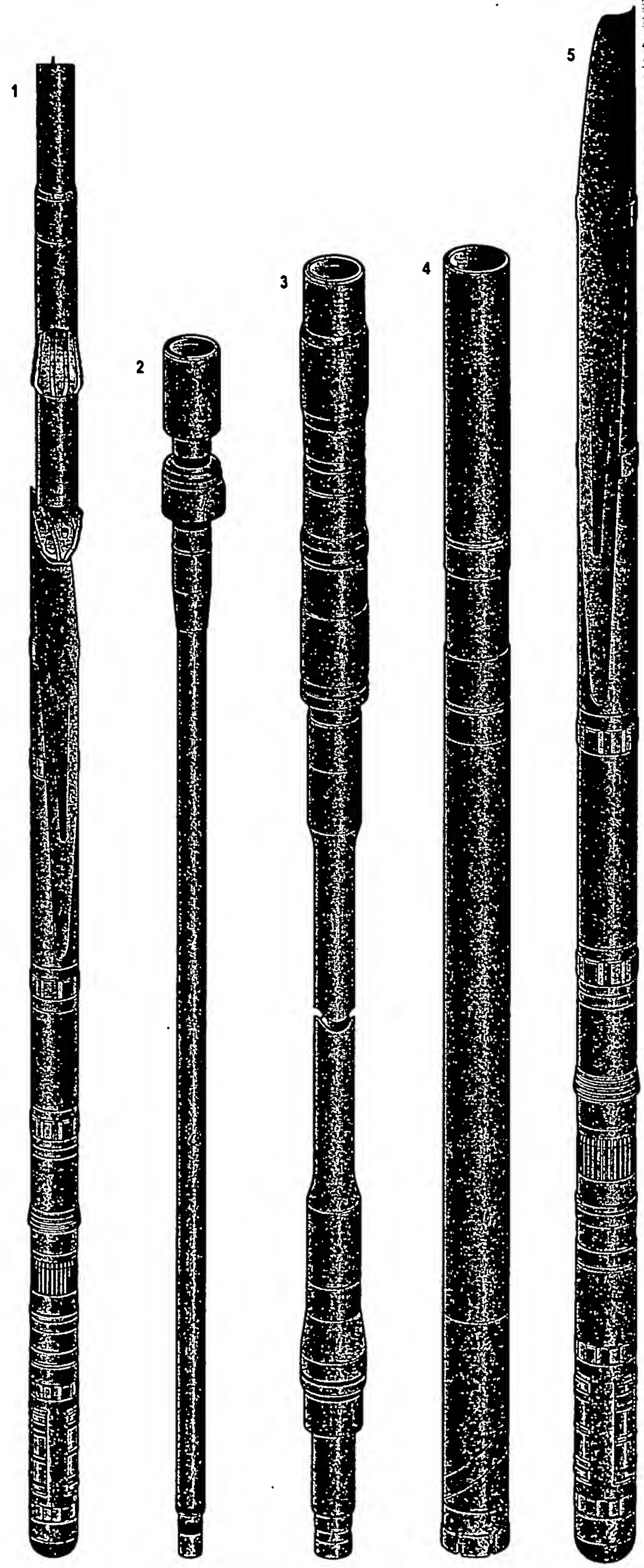
The MERLIN™ system is a multilateral junction construction system that uses casing milling to control the window geometry precisely for level 4 or 5 junctions.

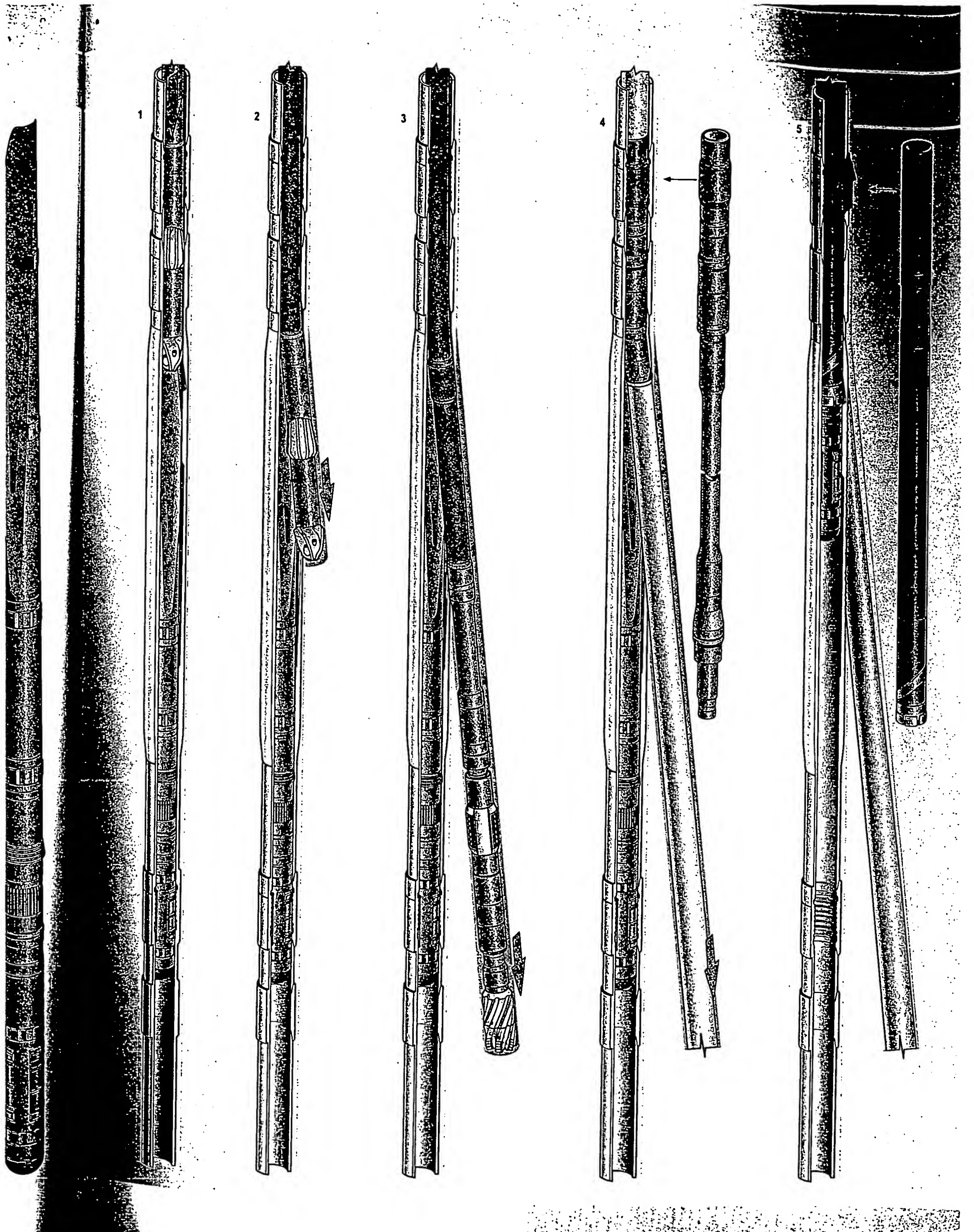
SYSTEM TOOLS: THIS PAGE

1. Drilling whipstock with bolted mills
2. Whipstock setting tool.
3. Transition joint running tool
4. Washover pipe with junkbasket
5. Washover whipstock

OPERATIONAL SEQUENCE: NEXT PAGE

1. Install MERLIN™ (Sperry-Sun/Smith International) milling assembly with bolted mills.
2. Mill window and retrieve milling whipstock.
3. Install RMLS™ washover whipstock and drill lateral.
4. Install lateral liner with transition joint and cement.
5. Washover lateral liner and retrieve washover whipstock.

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RDS™ Re-entry Drilling System

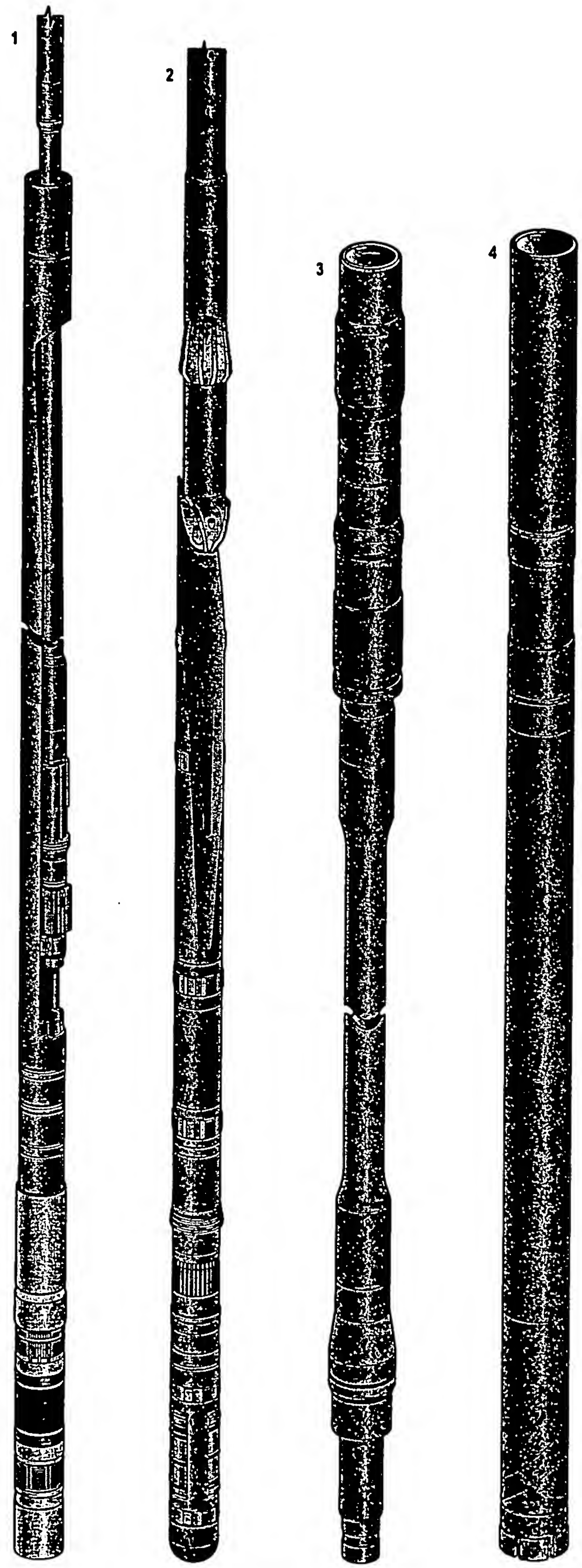
The RDS™ system is a multilateral junction construction system that uses a milling machine to create the multilateral window. This system can be used with the Sperry-Sun latch or a permanent downhole packer.

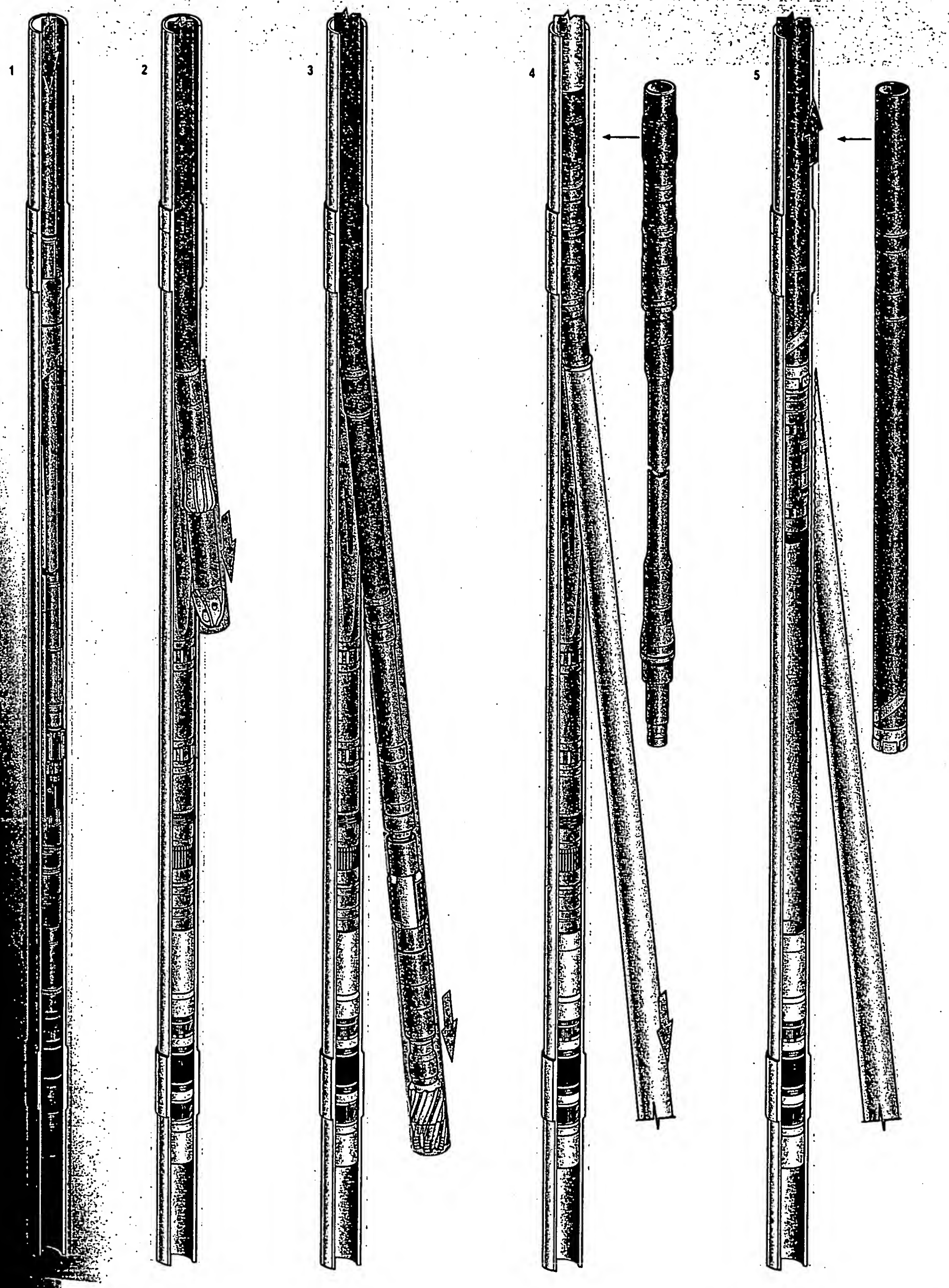
SYSTEM TOOLS: THIS PAGE

1. RDS™ milling machine
2. Drilling whipstock with bolted mills
3. Transition joint running tool
4. Washover pipe with junkbasket

OPERATIONAL SEQUENCE: NEXT PAGE

1. Install RDS™ milling machine and set anchor packer/latch coupling. Mill window and retrieve milling machine in one trip.
2. Install washover whipstock, dress junction, and drill lateral.
3. Install lateral liner with transition joint and cement.
4. Washover lateral liner and retrieve washover whipstock.

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LRS™ Lateral Re-entry System

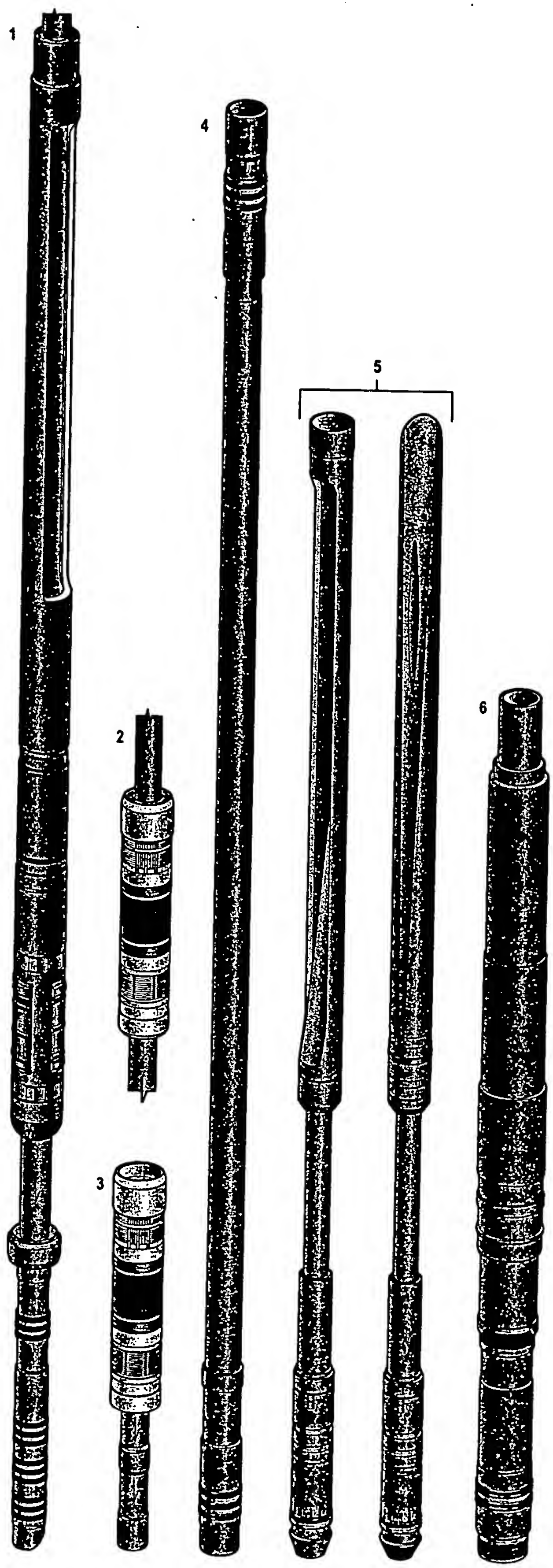
This multilateral well completion system allows through-tubing selective re-entry or isolation into both the lateral and the mainbores. TEW™ and TPI™ tools may be used with this system.

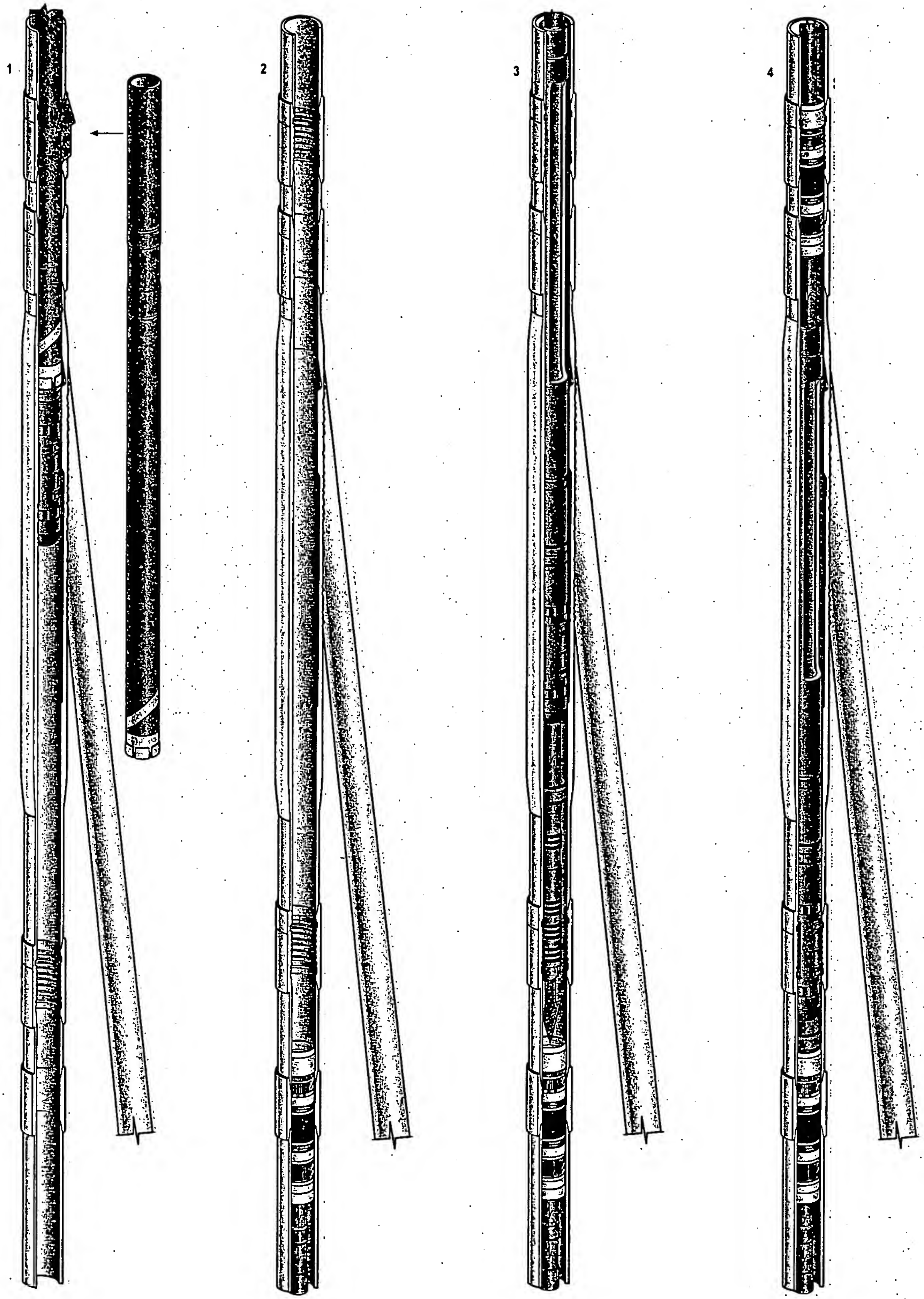
SYSTEM TOOLS: THIS PAGE

1. LRS™ window with latch
2. Upper packer assembly
3. Lower packer assembly
4. TPI™ sleeve
5. TEW™ whipstock (necked and neckless)
6. Torque lock packer setting tool

OPERATIONAL SEQUENCE: NEXT PAGE

1. RMLS™ pre-milled window shown with drilled out lateral and lateral liner installed.
2. Install lower packer assembly with tail pipe, nipple, and wireline entry guide.
3. Install lower seal assembly, LRS™ window, and upper packer assembly.
4. Install upper completion with upper seal assembly.

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LRS-SL™ Self-Locating Lateral Re-entry System

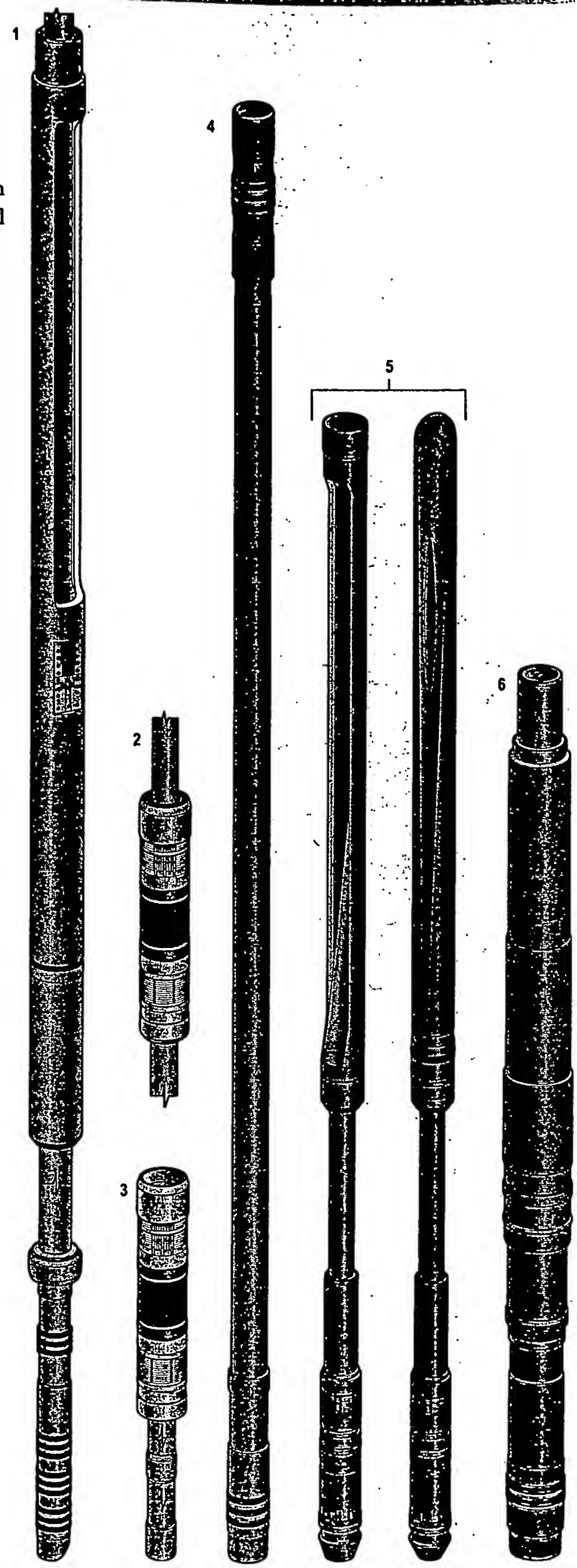
Self-orienting and self-locking lateral re-entry completion system that can be used in the junction of a multilateral window created by any system.

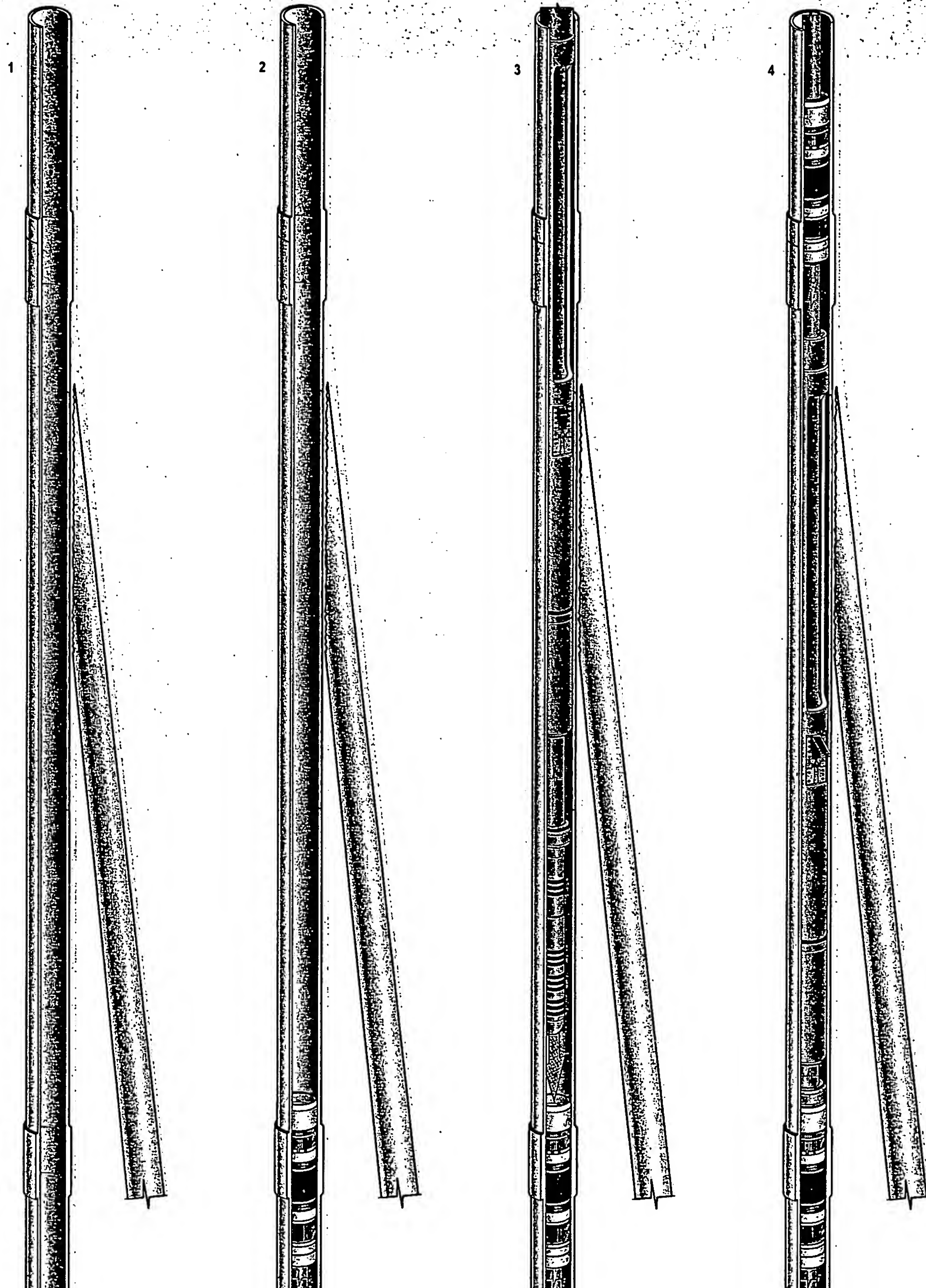
SYSTEM TOOLS: THIS PAGE

1. LRS™ window with self-locating key
2. Upper packer assembly
3. Lower packer assembly
4. TPI™ sleeve
5. TEW™ whipstock
6. Torque lock packer setting tool

OPERATIONAL SEQUENCE: NEXT PAGE

1. Conventional milled window shown with drilled out lateral and lateral liner installed.
2. Install lower packer assembly with tail pipe, nipple, and wireline entry guide.
3. Install LRS-SL™ window with self-locating key and upper packer assembly. Locate window opening and set anchor packer.
4. Install upper completion.

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MSCS® Multi-String Completion System

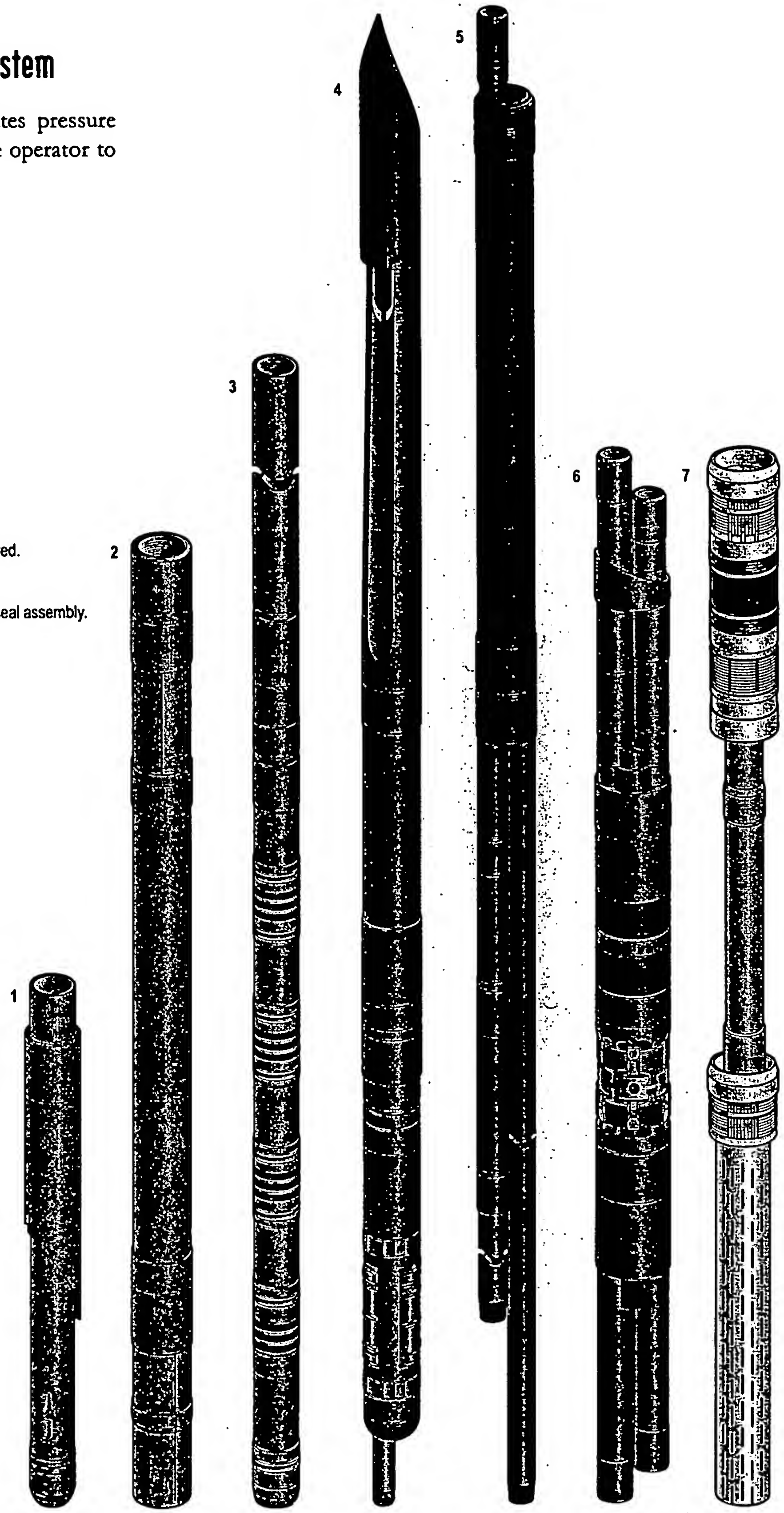
This multilateral completion system creates pressure integrity at a well junction and enables the operator to segregate or commingle production.

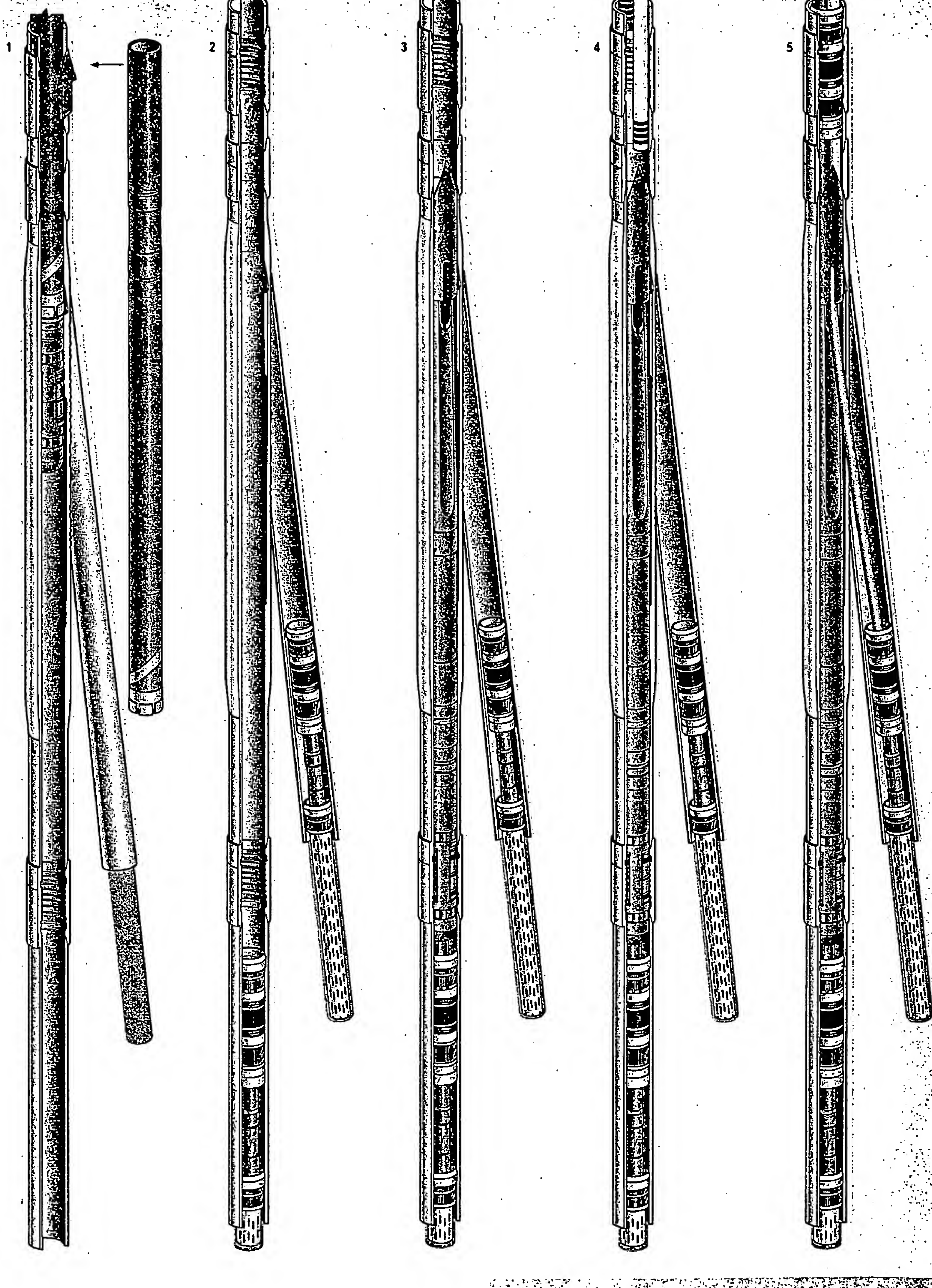
SYSTEM TOOLS: THIS PAGE

1. Hydro-mechanical retrieving tool
2. Lateral sheath assembly
3. Crimp seal stinger assembly
4. Dual-bore deflector
5. Vector block
6. Dual packer
7. Lower packer assembly

OPERATIONAL SEQUENCE: NEXT PAGE

1. RMLS™ whipstock is shown being washed over and retrieved.
2. Install lateral and lower mainbore packer assembly.
3. Install MSCS® dual-bore deflector with tail pipe and lower seal assembly.
4. Install dual tubing strings with seal assemblies.

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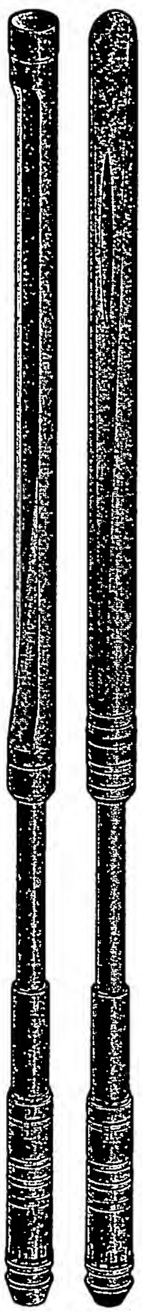
TPI™ Through-Tubing Pressure Isolation Sleeve

This is a completion system pressure isolation sleeve for the LRS™ and MSCS® systems.

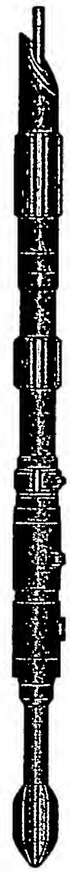
Vector Block

The vector block is used with the MSCS® system to enable selective access to either wellbore for drilling or completions (rig or rigless).



TEW™ Tubing Exit Whipstock

This is a completion re-entry deflector for the LRS™ and MSCS® systems.



WREAL™ Wireline Re-entry Alignment Whipstock

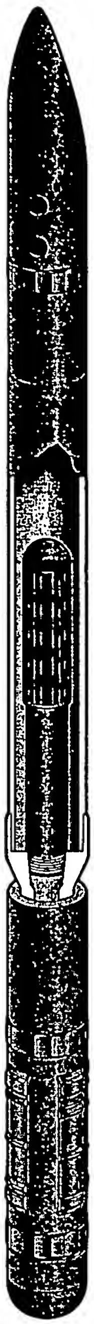
This completion whipstock is deployed by wireline or coiled tubing for access to the lateral bore with workover equipment.

‹ LRW™ Lateral Re-entry Whipstock

This workover whipstock is installed in the RMLS™ pre-milled window.

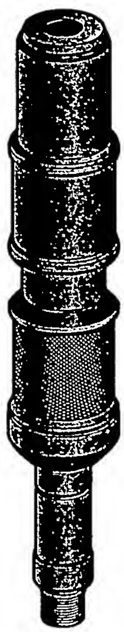
LRW-SL™ › Self-Locating Lateral Re-entry Whipstock

This workover whipstock is installed in the RMLS™ pre-milled window.



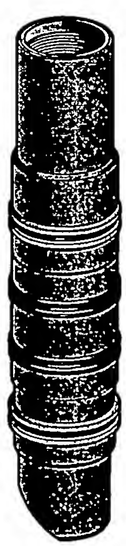
Debris Barrier Junk Basket

This barrier is used to protect completion equipment from debris such as that created by window milling. It is ideal for use with RDS™ or MERLIN™ systems, in which it is important to protect equipment below the milled junction from metal debris.



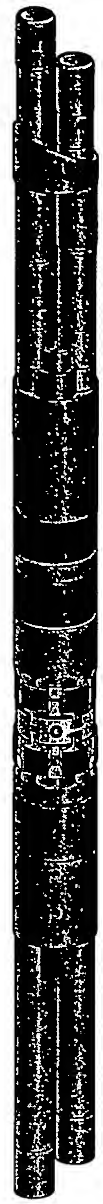
DPT

This is a wireline or coiled tubing running and retrieving tool for the TPI™ sleeve used with the LRS™ window or vector block.



Crimp Seal

This patented high-performance seal functions like a molded seal but can be easily re-dressed on the rig floor. It is used on seal stingers for the LRS™ and MSCS® systems.

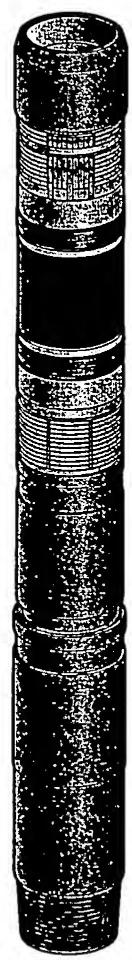


Retrievable Dual-Bore Packer

This is a retrievable hydraulically set dual sealbore packer that is used with the segregated flow MSCS® system.

PPH Packer

This torque-locked anchor packer is hydraulically set with a slip system enabling it to withstand 15,000 ft-lb of torque. The large bore makes it ideal for applications requiring access below the junction. This is typically run in conjunction with a latch coupling as an anchor for re-entry applications of the RDS™ or MERLIN™ systems.

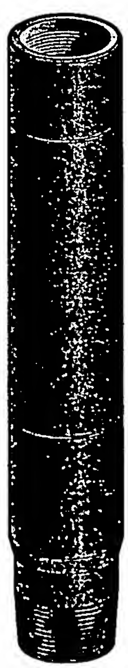


Retrievable Single-Bore Packer

This retrievable hydraulically set dual sealbore packer is used with the LRS™ or MSCS® systems. This packer is specially designed to allow easy installation into the lateral or to be used in conjunction with latching operations.

Torque-Locked Packer Setting Tool

This torque-locked hydraulic setting tool with anti-preset and hydraulic release features is used during the installation of the LRS™ or MSCS® systems.



Solid Glass Disc Sub

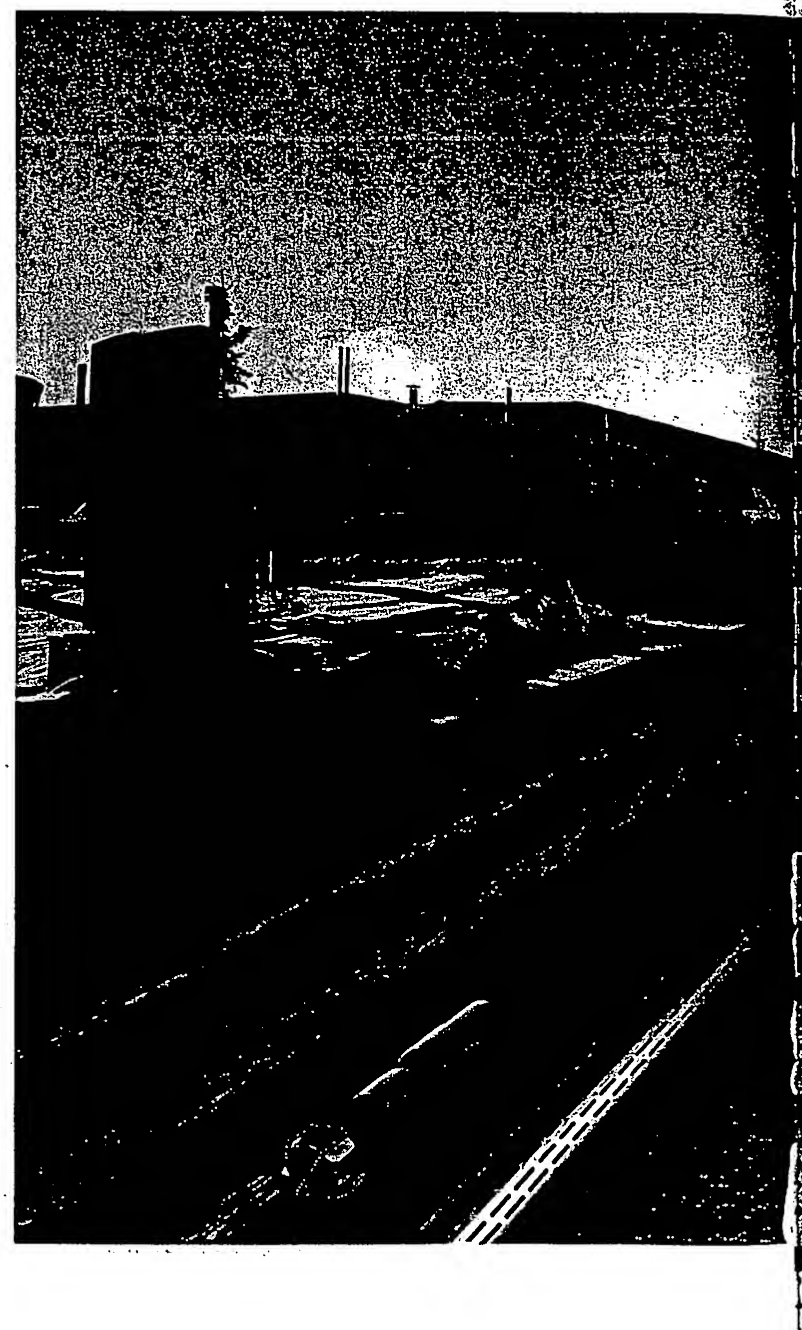
This is a pressure-activated tool with a pre-determined shear pressure that is used as a plug to operate downhole tools. After shearing, full ID is regained with only small, non-metallic fragments left in the hole.

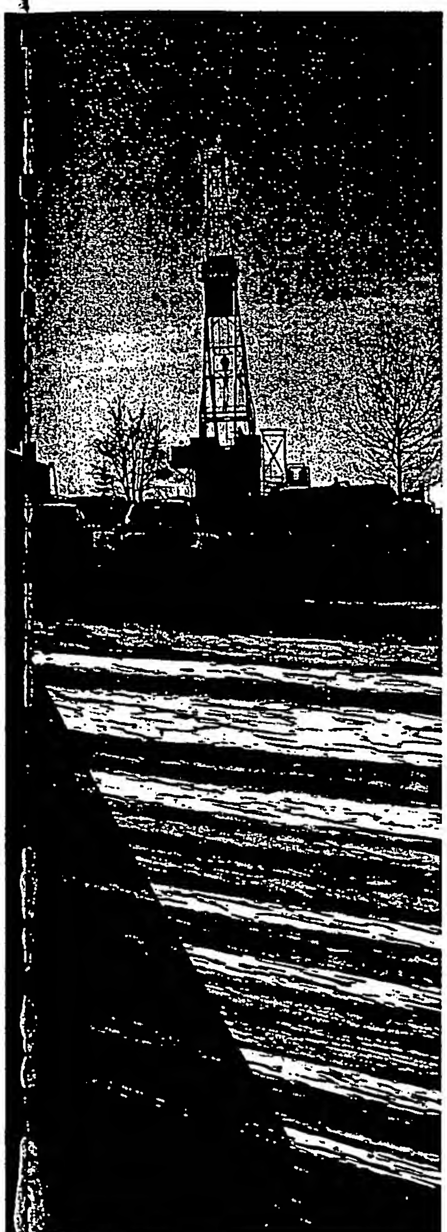
Planning

Planning Multilateral Projects with Sperry-Sun

The success of a project depends on proper planning, risk assessment, and well management. With more than 250 successful multilateral installations worldwide, Sperry-Sun provides you with the most experience to ensure a successful project. Sperry-Sun works closely with you to ensure that the multilateral project is properly managed and completed with the greatest potential for return on your investment. Communication and understanding of the technical and operational issues are key to a successful multilateral well. Our years of experience in designing and improving multilateral systems means that our systems are the most innovative and reliable technologies in the industry. Consequently, Sperry-Sun has the largest, most diverse array of multilateral equipment and personnel.

As part of Halliburton, the largest service provider to the oil and gas industry, Sperry-Sun dedicates much of its resources to research and development. Sperry-Sun can access the reservoir expertise, software, and hardware of the Halliburton Reservoir Decision Centers in Aberdeen, Caracas, and Houston. The Halliburton Reservoir Description Group provides field development planning, production enhancement, reservoir surveillance, and computed log products. The multidisciplinary staff of the group includes geologists, geophysicists, petrophysicists, log analysts, and reservoir engineers.



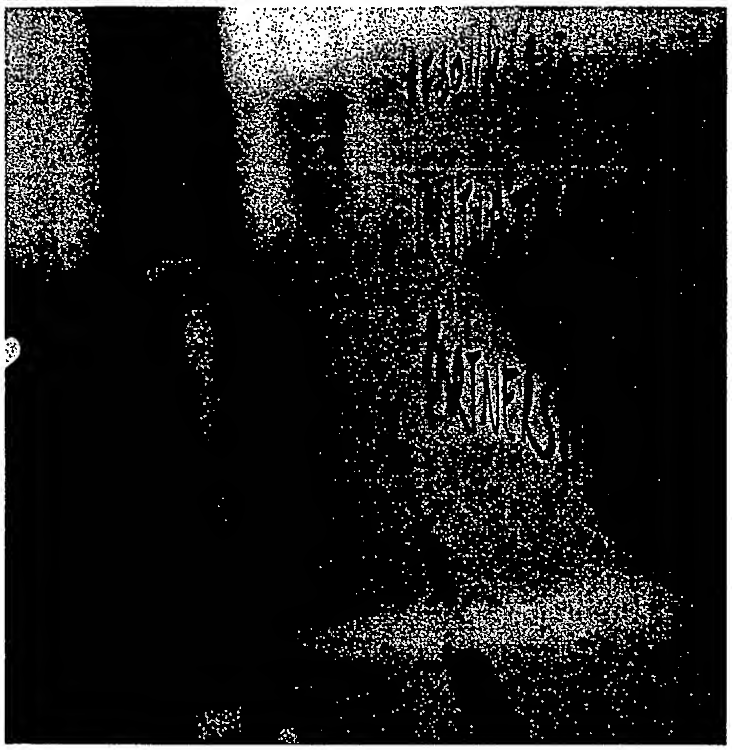


Myth: The time to delivery is long.

Reality: Planning and execution can be accomplished in 3 months or less, depending on the complexity of the project and application.

Applications

Multilateral Applications



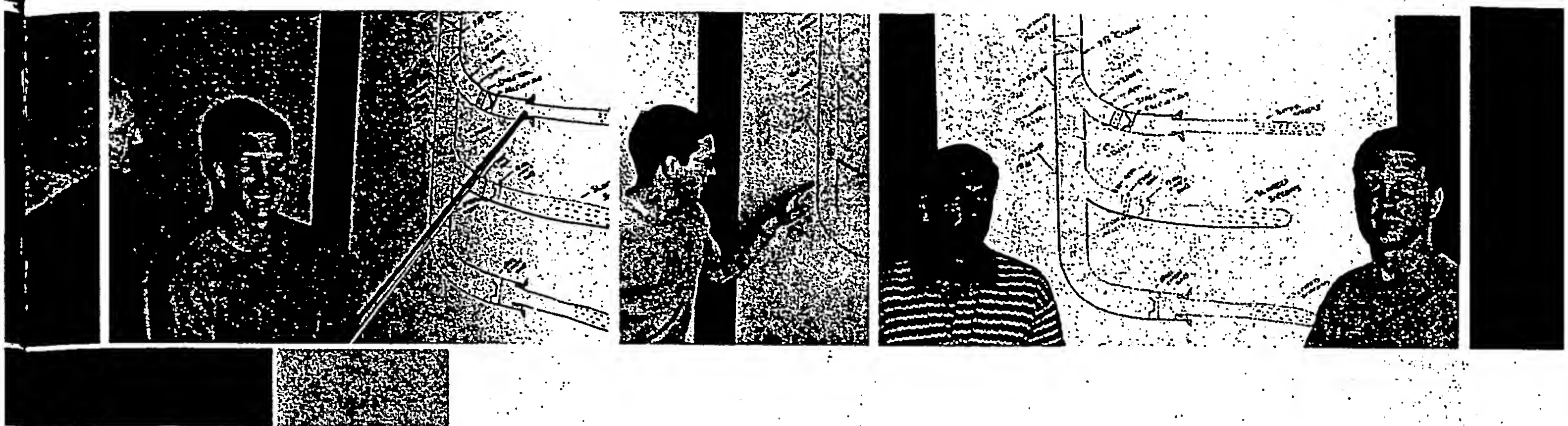
Designing Multilateral Wells

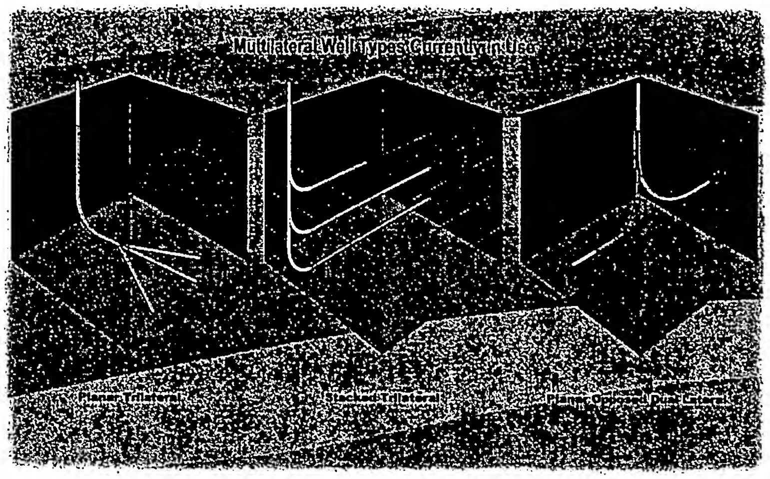
Successfully evaluating an individual well or field requires a thorough understanding of the reservoir. After analysis, we can realize the full economic potential and minimize the risk in drilling and completing a multilateral well. Careful examination of the target reservoir enables Sperry-Sun to provide cost savings through multilateral wells that increase reservoir drainage, produce attic oil, provide slot conservation, reduce surface facilities, increase stacked-pay and multiple-zone exploitation, facilitate re-entry, and reach compartmentalized zones.

When designed properly, multilateral wells can provide considerably higher productivity than conventional wells and can increase reservoir recovery at relatively low incremental costs when compared to conventional wells or field developments.

"Myth: Horizontal applications are the only applications.

Reality: 75% of all types of wells could be multilaterals, and there have been numerous non-horizontal multilateral installations."





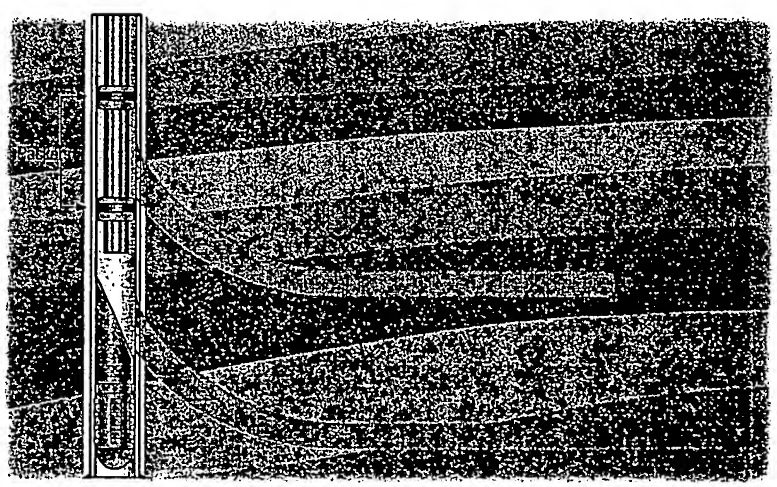
Increasing Reservoir Drainage

Because heavy oil is viscous and expensive to produce and refine, operators seek more economical methods to exploit the large reserves in Canada, the former Soviet Union, and Venezuela. Economically producing heavy oil requires placing as many branches as possible in the reservoir, which can most effectively be accomplished with multilateral technology. Consequently, operators find that a multilateral system provides greater flow rates that in turn increase the profits of heavy-oil exploitation.

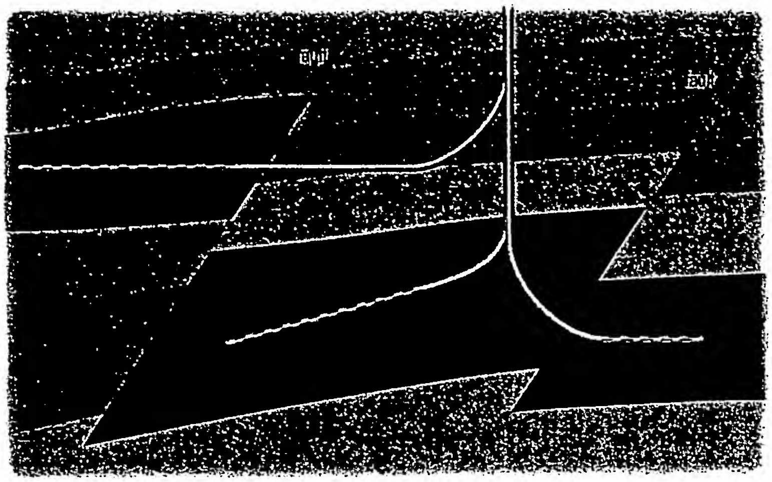
Multilaterals are especially good for producing hydrocarbons from hard formations with low porosity and permeability, such as chalk.

Stacked Pays and Multiple Zones

Reservoirs are often compartmentalized and layered with irregularly shaped geological flow units. A multilateral well can reach multiple zones within a reservoir and multiple reservoirs within an area, reducing drilling, production, and exploration costs. A multilateral can be placed in the middle of an area of stacked pays or between multiple zones. The operator can then drill from the mainbore to tap the surrounding areas. As a result, multilateral wells drilled from the same vertical mainbore can be independent, horizontal wells sidetracked at different points from the main vertical well.



A multilateral well can also be used to inject water to create a source of pressure so that the flood front starts as a roughly linear flow.

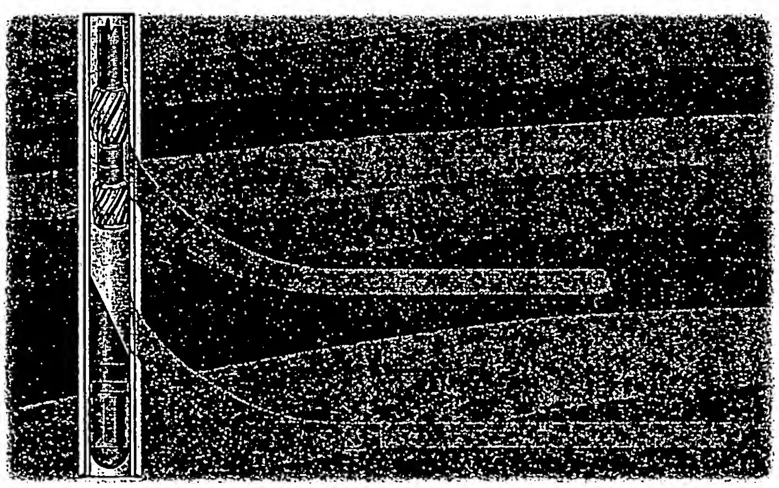


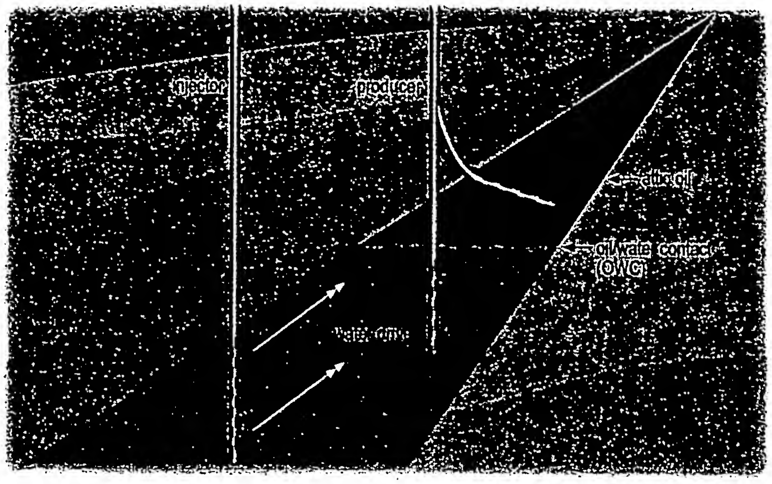
Compartmentalization

When vertical faults divide a field into numerous compartments, operators can only reach one zone per conventional well. Installing a multilateral system enables an operator to drill one mainbore through the middle of the faulted area and drill lateral bores off the main one that extend to the faulted zones. Multilateral well architecture saves drilling time and costs in these applications.

Re-entry

The greatest benefit to a re-entry well is the ability to extend the life cycle of an existing well. Through an existing wellbore, an operator can drill a lateral branch off the mainbore to reach new or additional reserves. The ability to avoid re-drilling the same footage to the top of the reservoir saves both time and money, producing a greater return on the well. As a reservoir is further developed, additional zones may be identified or become economical with a multilateral well. Re-entry applications take advantage of the existing assets and allow the latest drilling and completion technology to be deployed, many times exploiting zones that were not economical with earlier conventional processes.



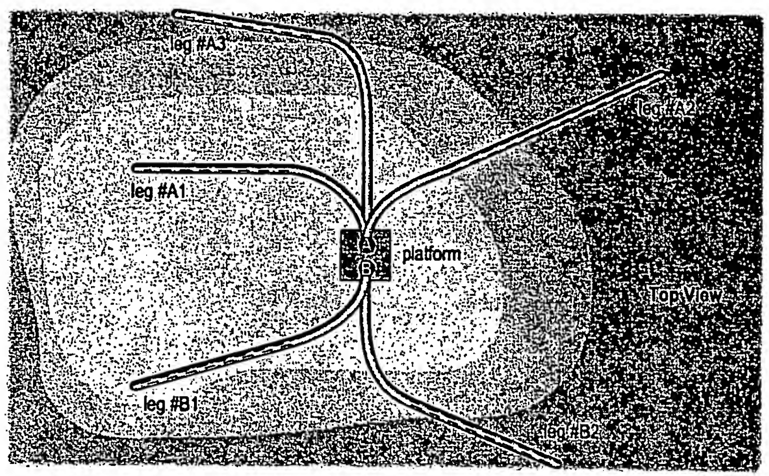


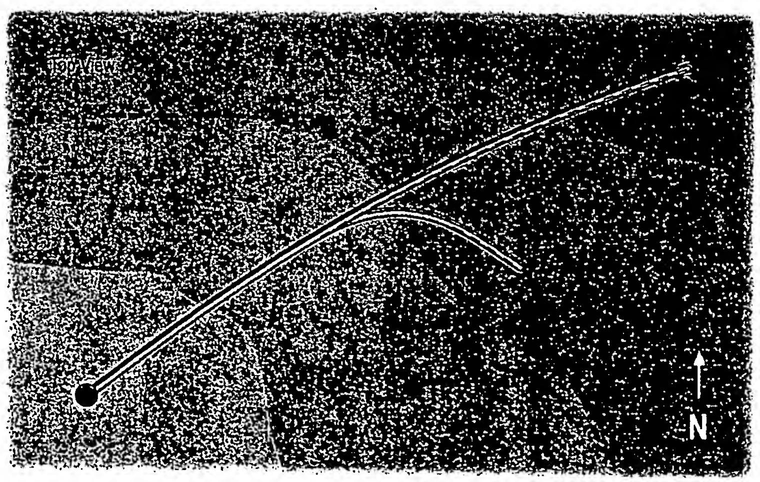
Attic Oil Recovery

Because oil and gas are lighter than water, hydrocarbons are often trapped above the highest perforations in the wellbore. Wells are often abandoned before the reservoir can be completely exploited. The operator can drill a multilateral wellbore off the existing mainbore to reach and recover the optimum amount of oil and gas from the attic of the reservoir.

Slot Conservation

On platforms and subsea developments, slot space is at a minimum and too few slots often exist to completely exploit an area. This requires the operator to choose between installing more slots or abandoning the area. Using multilateral technology, the operator can tap multiple zones per slot and reduce the number of costly slots required to produce a reservoir. If additional zones are discovered from an existing platform, re-entry multilateral systems can be used to tap and produce those new zones.





Reduced Surface Facilities

A large expense in both exploration and development drilling is the uphole and surface facilities cost. This is especially a factor in remote or seasonal locations where lease sizes and numbers, as well as pipelines and right-of-way access, can be very expensive. With fewer wellheads and increased rates of production, the production costs are also minimized. For example, a reservoir may require 24 conventional wells, but a multilateral solution only requires 6 multilateral wells. Consequently, a multilateral system reduces the number of required slots, saving 55 percent of the topside cost.

Design

Well Design Options

Technical Issues with Multilateral Design

Sperry-Sun employs the most experienced team of engineers in the industry to plan and execute your multilateral drilling and completions projects. The number of junctions, type of junction, and optimum placement of the junction are carefully planned according to the specific application. The type of multilateral completion is also evaluated to determine the level of re-entry, flow control, and isolation that are required. A detailed job checklist is jointly prepared with you and the Sperry-Sun team to ensure that all project information is communicated and understood at the start of the project, that realistic goals are set, and that the correct system for your application is chosen.

New Wells Versus Re-entry Wells

The key to a successful multilateral well lies in the creation of a good junction that connects the mainbore to the lateral bore. The technology to create multilateral junctions has developed using pre-milled window technology and milled window technology. In new wells, 75 percent of all level 2 and higher multilateral wells use pre-milled window technology.

New wells typically have fewer technical restrictions, making make them ideal candidates for multilateral installations. The preferred solution for a new multilateral well would include a pre-milled window system, reducing or eliminating any debris from milling operations. Self-aligning mechanisms incorporated in the pre-milled window joint allow for precise re-entry and alignment without restricting access to either wellbore. The controlled geometry of the pre-milled window is predetermined to minimize dogleg problems and ensure successful repeatable access to the lateral wellbore.

Although multilateral solutions have been commonly installed in new wells, the potential to recover an abundance of reserves exists for re-entry applications. New laterals can reach previously missed targets, extending the economic life of existing wells. Milled windows can be created in either new or existing casing. If the flexibility of milling out a window and full-gauge access to either wellbore is desired, then a Sperry-Sun latch coupling can be run in new wells.

What follows is a summary of the most important factors to be considered when planning a multilateral well.

Casing and Cementation

- Casing size
- Lateral hole size
- Lateral liner size
- Cementing placement for the mainbore and lateral bore
- Sand control with slotted screens or perforated pipe

Junction Integrity

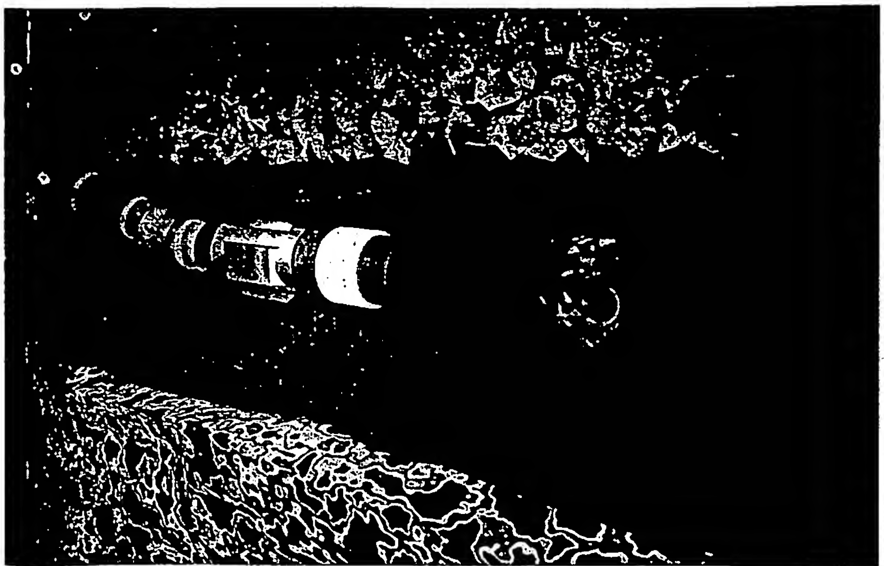
- Mechanical tie-back of lateral liners
- Sand production control
- Formation stability
- Junction longevity
- Hydraulic integrity

Completion and Production

- Commingled or segregated production
- Flow control and isolation requirements

Accessibility

- Accessibility of the mainbore and lateral bore
- Through-tubing access
- Non-rig intervention



Well Architecture

The decision to drill a multilateral well is based on several criteria, including an evaluation of the technical issues, risk assessment, and economic performance. Determining the functional requirements of the multilateral well is crucial as to which method and system are selected for the multilateral well design.

Reservoir engineering needs to consider the degree of communication among the drainage areas of the individual branches of the multilateral system. The correct well architecture and completion equipment selection will allow optimum production of a reservoir. Three major drainage patterns are likely, and combinations of all three are possible:

- Single layer in which an anisotropic permeability in the reservoir is critical, requiring a horizontal main wellbore with multiple lateral bores
- Several stacked layers that may or may not communicate, requiring a vertical main wellbore with multiple lateral bores
- Several compartments in a reservoir that may or may not communicate, requiring a horizontal main wellbore with multiple lateral bores

It is important that the project planning include the degree of flow control and selective wellbore management that the completed multilateral well will require. The ability to produce several reservoirs simultaneously and individually is a benefit of the multilateral systems.

Because of the flexibility of multilateral solutions, three flow configurations are possible:

- Commingled production of the reservoirs
- Commingled production with individual branches that can be shut off and re-entered easily
- Individual production with tubing tied back to the surface

Multilateral completions are available to meet the need for selective wellbore control with full connectivity, isolation, and selective access to the mainbore and lateral bore. Evaluation of the re-entry requirements should drive the selection of the multilateral completion system.

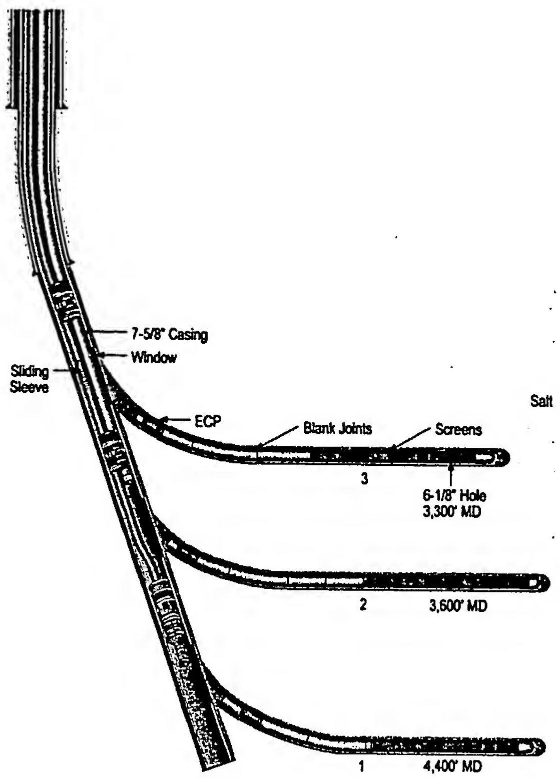
The following pages show common multilateral architecture used for the different applications.

Myth: Multilateral wells are associated with excessive risk.

Reality: By definition, multilateral wells are associated with a more complex well design.

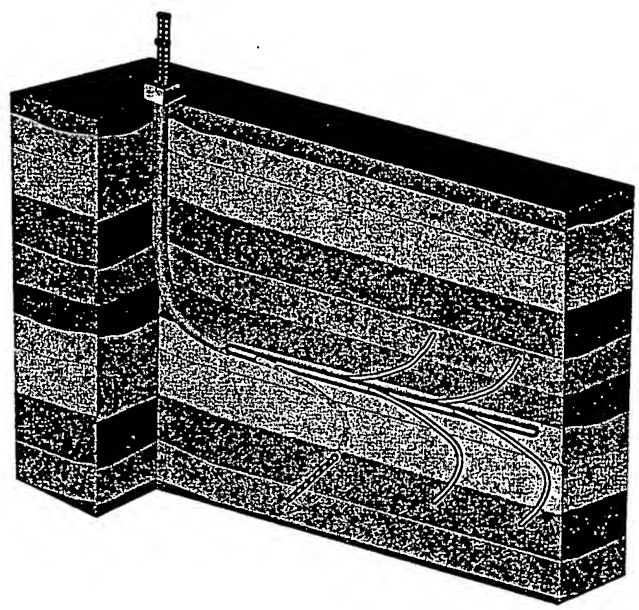
Stacked

Depleted reservoirs can benefit from the use of a stacked multilateral architecture. The laterals increase the reservoir exposure, minimizing draw down pressure. Intermediate or short-radius technologies reduce the vertical distance for the build section. It is important that there is no restriction on the mainbore so a pump can be placed below the lowest junction. Oil can then freely flow into the mainbore sump to be pumped to the surface.



Five Splayed Legs for Heavy-Oil Wells

Multilateral systems that control sand production at the junction enable multiple junctions to be installed along a horizontal, allowing increased reservoir exposure. Applying a splayed multilateral architecture in heavy-oil projects has yielded up to 2,800 meters of wellbore exposure from a single parent wellbore. The individual ribs can be positioned to access a broad expanse of the oil sands.



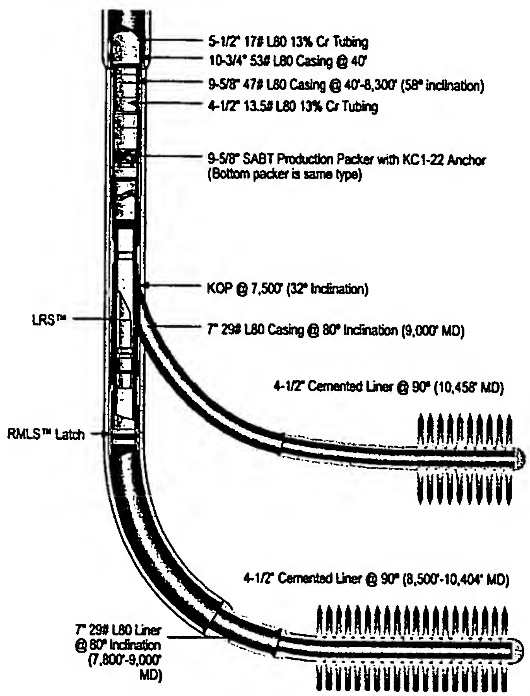
Dual-Opposing Up Dip and Down Dip Laterals

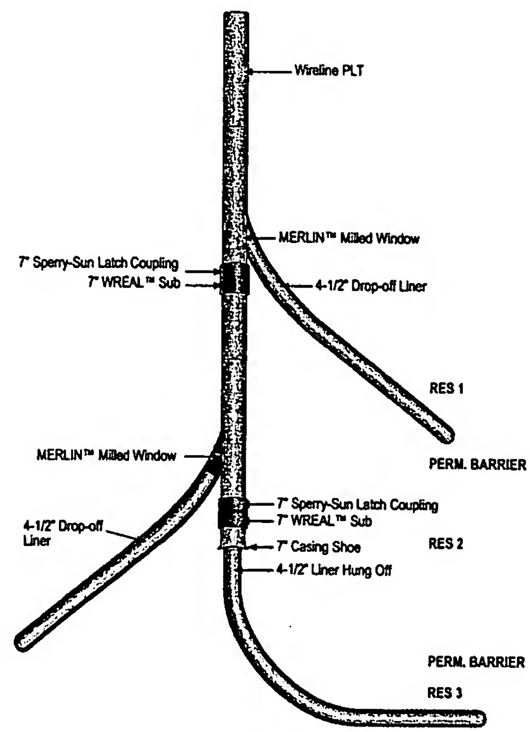
A dual-opposing architecture uses a single junction. The configuration accesses an extended vertical section of a reservoir with multiple lateral bores.

A unique application of multilateral technology is the use of a junction in exploration before the selection of a target. The drilling of a vertical lower mainbore can be used to prove multiple stratified pay zones. After the most prolific layers have been determined, the lateral directional profile can be tailored to place a horizontal at the ideal depth.

Stacked for the Drainage of Multiple Reservoirs

Secondary targets can be added to a well development plan. Multiple different targets may be added to improve the economic potential from a primary reservoir. Production from different targets may be commingled or segregated, depending on the completion system selected. Current multilateral completion systems offer several options for commingled, segregated, through-tubing re-entry access, isolation, and flow control if required.





Branched for Fractured Carbonates

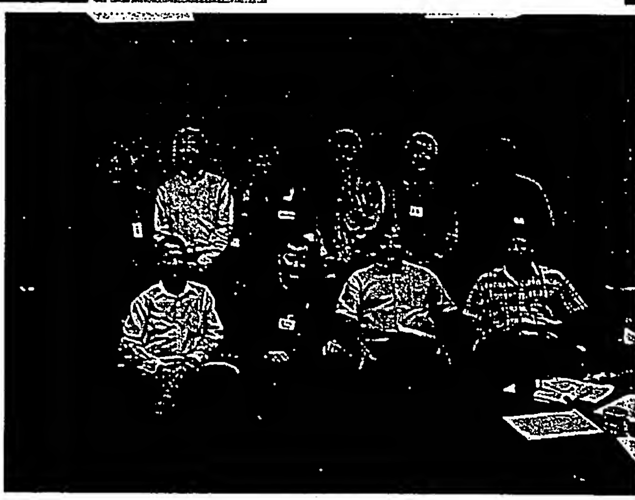
Access to multiple fractured reservoirs can be accomplished using fewer wells or surface locations by the use of multiple laterals. The unproductive footage is drilled only once, with each additional lateral increasing the amount of reserves tapped.

Management

Sperry-Sun Project Management

The project management of a multilateral well is crucial to coordinate equipment logistics, operations, and contingency planning before and during the junction construction. To ensure success, Sperry-Sun follows a series of steps to manage the project through junction construction, completion, and production.

1. The customer has a dedicated contact person or engineering team to work closely with the Sperry-Sun application and operation team.
2. The combined team works together to understand the operations needed for a successful implementation and installation and to develop contingencies for any unforeseen problems. The ability to react quickly to situations as they develop can determine the overall economic success of the venture.
3. The team sets the specific project goals. The plan to access the reservoir using multilateral technology is based on Sperry-Sun's experience and specialized systems. The team ensures that both organizations and actions are directed to meet the goals. The main goal of every project is to ensure that the multilateral solution produces the optimum economic benefits for the customer.
4. All decisions made throughout the duration of the project are recorded for post-project review.
5. The team accurately monitors performance with respect to the project goals. The team reviews the procedures and verifies that they will be correctly applied at the start of the project.
6. The team makes use of Sperry-Sun's experience and the project records to create future practices for the next application.



An experienced Sperry-Sun multilateral project engineer/ coordinator manages the project, and a multilateral field specialist is on location for each multilateral operation. Sperry-Sun recognizes that drilling operators have established methods and tools for drilling single-bore wells. However, with more than 250 successful multilateral installations worldwide, Sperry-Sun has the knowledge to design, drill, and complete a multilateral well safely. Multilateral wells are not conventional wells and sometimes require new approaches to overcome unique operational difficulties. Therefore, success in multilateral well projects requires adapting to new ideas and methods of operations.

Multilateral wells, in many instances, have been the best producing wells compared with more conventional wells in the same field, even when compared economically.

Pre-Planning

Although the overall benefits of a multilateral installation can be tenfold, the project can require 25-50 percent more time for engineering and planning. Pre-planning is essential in identifying potential design, equipment, or operational issues. Multilateral projects will typically involve a number of different products and services that all have specialized procedures. It is important that all the equipment and specialized procedures work smoothly together, especially with respect to multilateral operations. Due to the complexity and learning curve of some multilateral operations, it may be a temptation for some project engineers and rig foremen to shortcut the multilateral operations. Following the planned process is key to a successful operation.

Well Economics

Economics is one of the primary drivers for installing multilateral wells. The ability to reduce surface or uphole costs while maintaining or increasing the reservoir exposure increases the overall return on the well development. Despite the initial higher costs, multilateral wells can have significant financial advantage. When the reservoirs are thin or contain unfavorable permeability barriers, faults, or other features, the desired cost goals are almost impossible to reach with conventional or horizontal wells. In these cases, multilateral wells can provide economic benefits by tapping difficult-to-reach reservoirs. The goal in all these strategies is to determine the application that provides the best net present value (NPV).

Sperry-Sun also takes advantage of new technologies, such as smart well, downhole separators, and steam-assisted gravity drainage, to improve the economics of multilateral well technology.

Operator Benefits

In addition to increasing the NPV of a project and accelerating production, multilateral wells reduce the number of wells drilled and slots consumed. A substantial portion of uphole drilling and equipment costs can also be eliminated with multilateral systems. Marginal wells can connect multiple targets with multilateral technology, making a field development viable that would otherwise not be viable. Economical fields can use multilateral technology to access additional reserves that will extend the production life of a well.

Multilateral wells that optimize reservoir management provide operators with the opportunity to improve productivity and reservoir drainage. With Sperry-Sun's optimized reservoir management, operators can also position the multilateral wellbore to target the hydrocarbons in the most efficient design. The variety of multilateral completion options enables the well completion to be tailored to the specific reservoir. Multilateral completion technology allows selective through-tubing re-entry, commingled production, and isolation.

To evaluate the economics of a multilateral installation to give the greatest return on your investments, use the following calculation:

Comparison Evaluation

$$PV = \sum_{n} \left[\frac{Q_o P_r \left(1 - \frac{D_r}{m}\right)^{n-1} N_b D}{\left(1 + \frac{i}{m}\right)^{n}} \right]$$

where:

$m = 12$
$n = m \times y$
$i = 0.25$
$N_b = 10$
$Q_o = 2500$
$D = 30$

PV = present value ($)
i = discount rate (fraction)
m = periods per year
Q_o = initial flow rate (bbl/day)
D_r = decline rate (fraction)
D = days per period (days)
n = total number of periods
P_r = productivity ratio
N_b = net back ($/bbl)

Present Value of a Horizontal Well
$P_r = 1 \quad D_r = 0 \quad PV = 18.9\$mm$

Present Value of a Multilateral Well
$P_r = 3 \quad D_r = 0 \quad PV = 56.6\$mm$

Present Value of a Multilateral Well
$P_r = 3 \quad D_r = 0.12 \quad PV = 48.8\$mm$

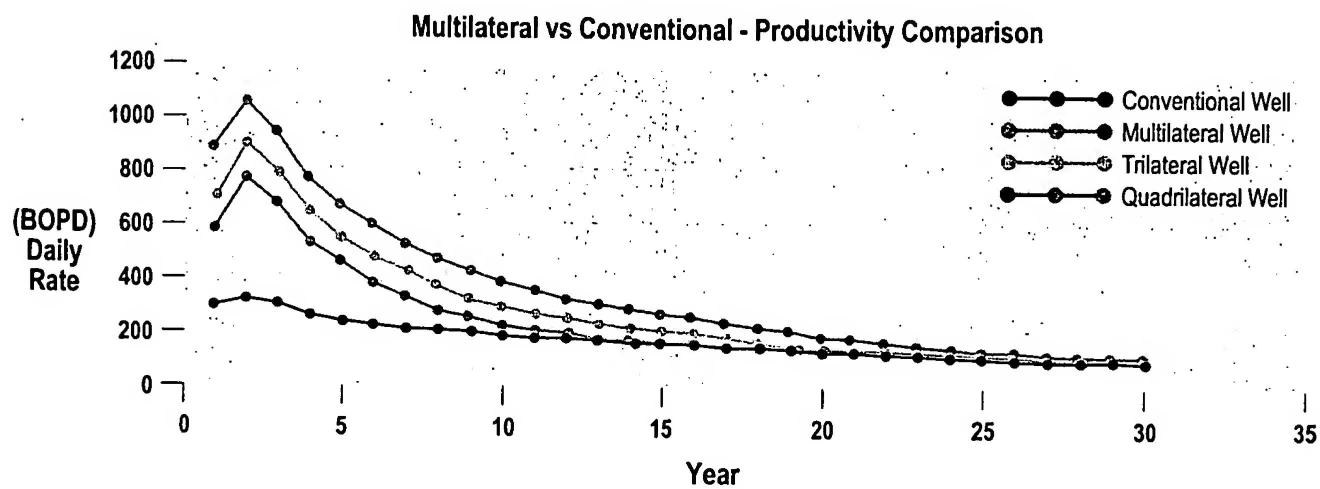
Risk Assessment

Sperry-Sun realizes that multilateral technology is relatively new to the industry and that building a valid business case often presents challenges because of the lack of historical data. Sperry-Sun has more experience than anyone else in the industry in the drilling and completion of multilateral wells. Sperry-Sun has field-proven, reliable systems that include many improvements to reduce operational risks. New multilateral system development builds upon previous successful designs and new improvements to produce the best systems in the industry. Detailed operational and contingency planning ensures a smooth multilateral installation. All lessons learned in the field are recorded for a central technical group that is responsible for identifying and redistributing a set of best practices for each multilateral system.

Sperry-Sun also uses quantitative risk analysis in the multilateral well planning process. In the analysis, multiple simulated outcomes produce a range of consequences, which are quantified in economic terms. By reviewing the results, the customer and Sperry-Sun representatives better understand the risks in terms of potential economic effects.

In evaluating the risks of multilateral technology, it is important to note that many multilateral installations to date have been technically difficult. Half of all Sperry-Sun multilateral junctions have been installed at depths from 3,000 to 7,000 feet, with some installed below 14,000 feet. Three-quarters of the multilateral junctions have been set in hole angles greater than 60 degrees.

Sperry-Sun has designed multilateral junctions that provide reliable re-entry of the lateral bore for drilling, lining, and installing completions. The Sperry-Sun latch coupling provides a permanent reference and precise axial and radial alignment to the window aperture. Debris is controlled in the main and lateral bore by using debris management devices or debris-reducing technology, such as pre-milled window technology. A successful multilateral well depends on patiently following operational steps.

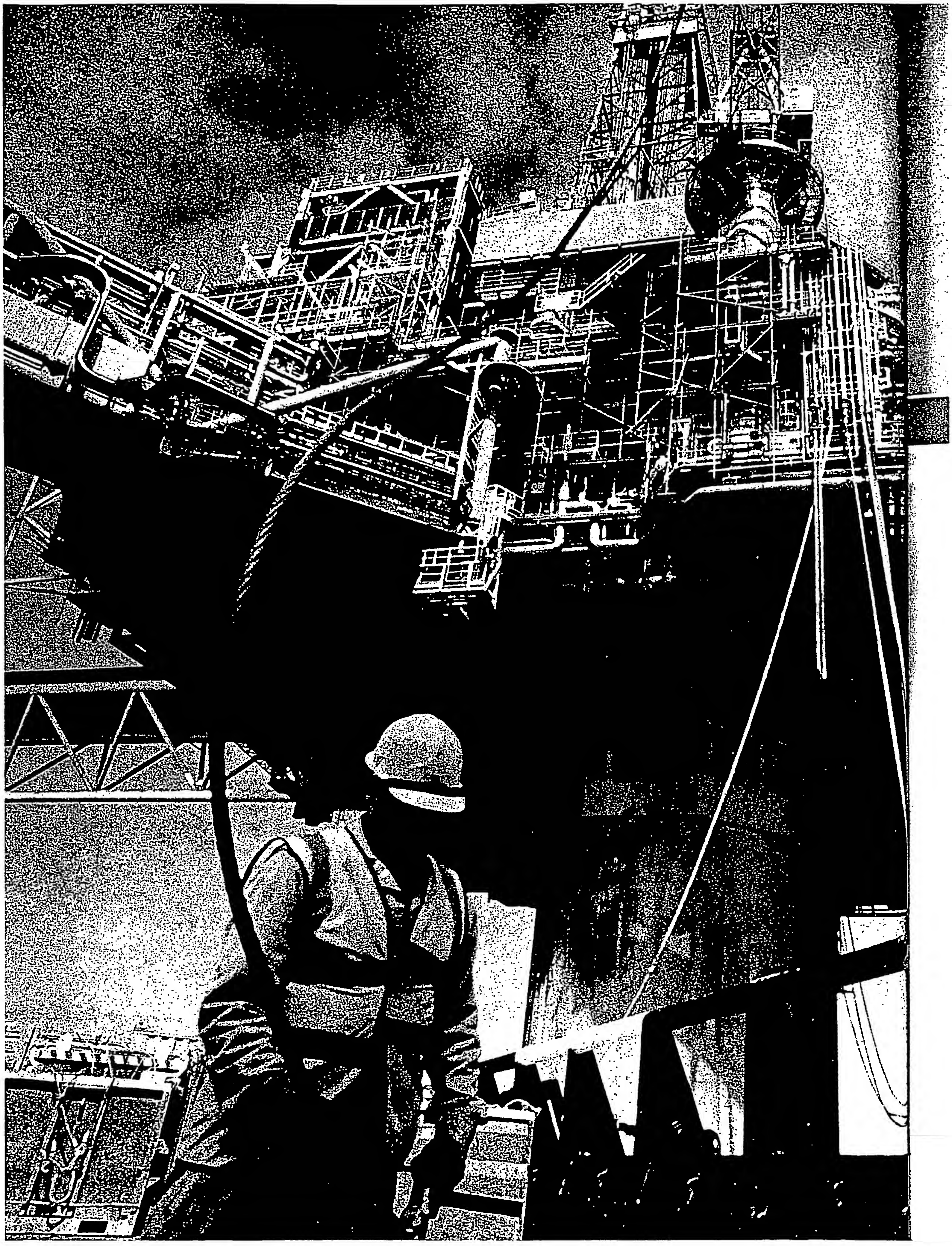


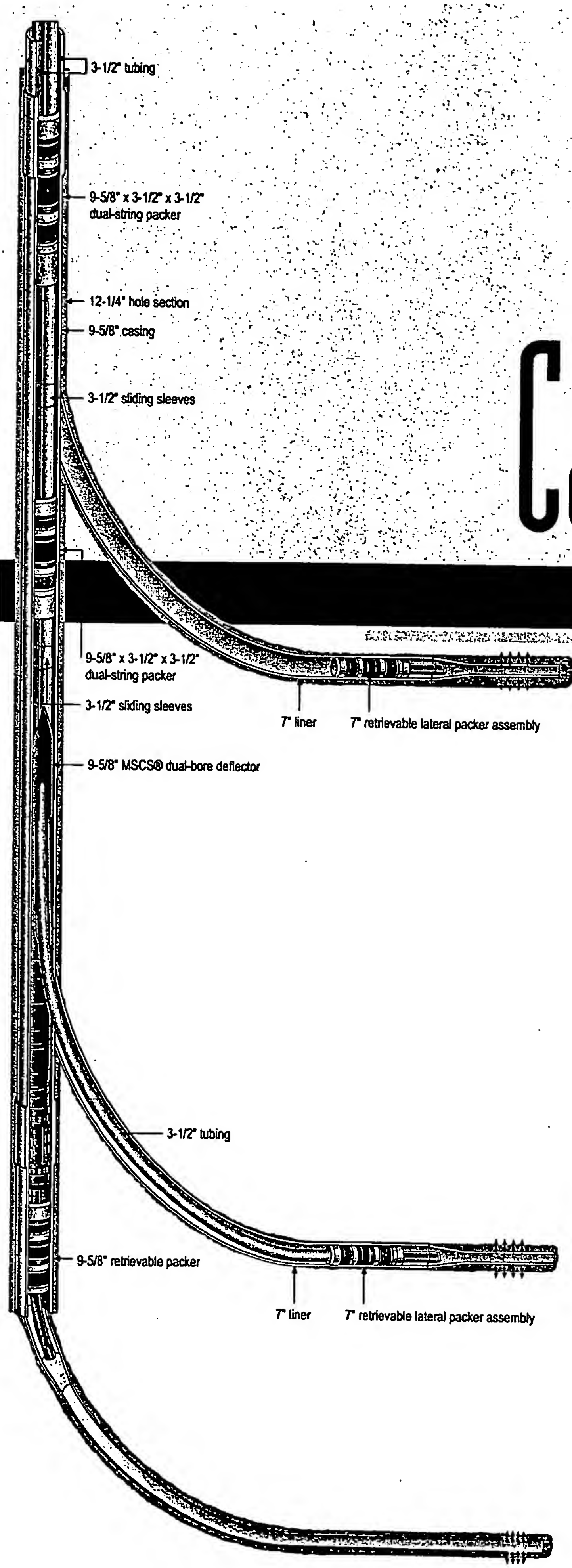
Multilateral Junction Decision Chart

		New or Re-entry	Debris-Free System	Casing Mainbore Access	Casing Lateral Access	Drill Out Top Down or Bottom Up	Sand Control at Junction
Level 2	LTBS™	new	yes	full gauge	reduced	either	no
• lateral open hole (all)	RMLS™	new	yes	full gauge	full gauge	either	no
• lateral drop liner (all)	MERLIN™	new	no	full gauge	full gauge	either	no
		re-entry	no	reduced	full gauge	bottom up	no
	RDS™	new	no	full gauge	full gauge	either	no
		re-entry	no	reduced	full gauge	bottom up	no
Level 3 - mechanical tie-back	LTBS™	new	yes	full gauge	reduced	either	limited
Level 3 - mechanical hanger	RMLS™	new	yes	reduced	full gauge	either	limited
	MERLIN™	new	no	full gauge	full gauge	either	limited
		re-entry	no	reduced	full gauge	bottom up	limited
	RDS™	new	no	full gauge	full gauge	either	limited
		re-entry	no	reduced	full gauge	bottom up	limited
Level 4 - cemented tie-back	LTBS™	new	yes	full gauge	reduced	either	cement
Level 4 - cemented junction	RMLS™	new	yes	full gauge	full gauge	either	cement
	4501™	new	no	flow	full gauge	bottom up	cement
		re-entry	no	flow	full gauge	bottom up	cement
	4502™/4503™	new	no	full gauge	full gauge	bottom up	cement
		re-entry	no	reduced	full gauge	bottom up	cement
	MERLIN™	new	no	full gauge	full gauge	either	cement
		re-entry	no	reduced	full gauge	bottom up	cement
	RDS™	new	no	full gauge	full gauge	either	cement
		re-entry	no	reduced	full gauge	bottom up	cement
Level 5 - completion whipstock	MSCS®	new	yes	tubing string	tubing string	either	completion
		re-entry	yes	tubing string	tubing string	bottom up	completion
Level 5 - flexible hanger	ITBS™	new	yes	reduced	reduced	bottom up	casing
Level 6 - inflatable junction	PACE-6™	new	yes	reduced	reduced	bottom up	casing

Completion Systems Decision Chart

Level	System	Completion Systems	System Compatibility	Junction Hydraulic Isolation	Through-Tubing Mainbore Re-entry	Through-Tubing Lateral Re-entry	Ability to Stack Wells
Level 2 • lateral open hole • lateral drop liner	LTBS™	single string	yes	none	yes	no	yes, commingled
		dual string	yes	none	yes	no	yes, commingled
		MSCS®	yes	packer sealed junction	yes	yes	yes, segregated
		LRS™	yes	packer sealed mainbore	yes	yes	yes, commingled
	RMLS™	single string	yes	none	yes	no	yes, commingled
		dual string	yes	none	yes	no	yes, commingled
		MSCS®	yes	packer sealed junction	yes	yes	yes, segregated
		LRS™	yes	packer sealed mainbore	yes	yes	yes, commingled
	MERLIN™	single string	yes	none	yes	no	yes, commingled
		dual string	yes	none	yes	no	yes, commingled
		MSCS®	yes	packer sealed junction	yes	yes	yes, segregated
		LRS™	yes	packer sealed mainbore	yes	yes	yes, commingled
	RDS™	single string	yes	none	yes	no	yes, commingled
		dual string	yes	none	yes	no	yes, commingled
		MSCS®	yes	packer sealed junction	yes	yes	yes, segregated
		LRS™	yes	packer sealed mainbore	yes	yes	yes, commingled
Level 3 • mechanical tie-back • mechanical hanger	LTBS™	single string	yes	none	yes	no	yes, commingled
		dual string	yes	none	yes	no	yes, commingled
		MSCS®	yes	packer sealed junction	yes	yes	yes, segregated
		LRS™	yes	packer sealed mainbore	yes	yes	yes, commingled
	RMLS™	single string	yes	none	yes	no	yes, commingled
		dual string	yes	none	yes	no	yes, commingled
		MSCS®	yes	packer sealed junction	yes	yes	yes, segregated
		LRS™	yes	packer sealed mainbore	yes	yes	yes, commingled
	MERLIN™	single string	yes	none	yes	no	yes, commingled
		dual string	yes	none	yes	no	yes, commingled
		MSCS®	yes	packer sealed junction	yes	yes	yes, segregated
		LRS™	yes	packer sealed mainbore	yes	yes	yes, commingled
	RDS™	single string	yes	none	yes	no	yes, commingled
		dual string	yes	none	yes	no	yes, commingled
		MSCS®	yes	packer sealed junction	yes	yes	yes, segregated
		LRS™	yes	packer sealed mainbore	yes	yes	yes, commingled
Level 4 • cemented junction	RMLS™	single string	yes	cemented junction	yes	no	yes, commingled
		dual string	yes	cemented junction	yes	no	yes, commingled
		MSCS®	yes	packer sealed junction	yes	yes	yes, segregated
		LRS™	yes	packer sealed mainbore	yes	yes	yes, commingled
	4501	single string	yes	cemented junction	no	yes	yes, commingled
		dual string	yes	cemented junction	no	yes	yes, commingled
		MSCS®	no				
		LRS™	no				
	4502™/4503™	single string	yes	cemented junction	yes	no	yes, commingled
		dual string	yes	cemented junction	yes	no	yes, commingled
		MSCS®	no				
		LRS™	yes	cemented junction	yes	yes	yes, commingled
	MERLIN™	single string	yes	cemented junction	yes	no	yes, commingled
		dual string	yes	cemented junction	yes	no	yes, commingled
		MSCS®	yes	packer sealed junction	yes	yes	yes, segregated
		LRS™	yes	packer sealed mainbore	yes	yes	yes, commingled
	RDS™	single string	yes	cemented junction	yes	no	yes, commingled
		dual string	yes	cemented junction	yes	no	yes, commingled
		MSCS®	yes	packer sealed junction	yes	yes	yes, segregated
		LRS™	yes	packer sealed mainbore	yes	yes	yes, commingled
Level 5 • dualbore deflector • flexible hanger	MSCS®	System included in completions aspect of chart for each multilateral junction system.					
	ITBS™	no completion	yes	flexible hanger	yes	yes	yes, commingled
		single string	yes	flexible hanger	yes	no	yes, commingled
		dual string	yes	flexible hanger	yes	no	yes, commingled
		MSCS®	no				
		LRS™	no				
Level 6 • inflatable junction	PACE 6™	single string	yes	inflatable junction	yes	no	yes, commingled
		dual string	yes	inflatable junction	yes	no	yes, commingled
		MSCS®	yes	packer sealed junction	yes	yes	yes, segregated
		LRS™	yes	packer sealed mainbore	yes	yes	yes, commingled





Case Studies

Petronas Carigali Offshore Malaysia RMLS™ and MSCS® Multilateral Project

The Sotong oilfield is located offshore peninsular Malaysia in the South China Sea. A field program was planned to develop an oil reservoir using Sperry-Sun multilateral technology. Above the reservoir is a gas cap that is overlaid by shale. A weak aquifer underlies the oil reservoir. Due to the marginal economics of this small field, it was decided to utilize multilateral technology, which would enable the use of a smaller platform with a reduced number of slots compared to what would be required for conventional drilling.

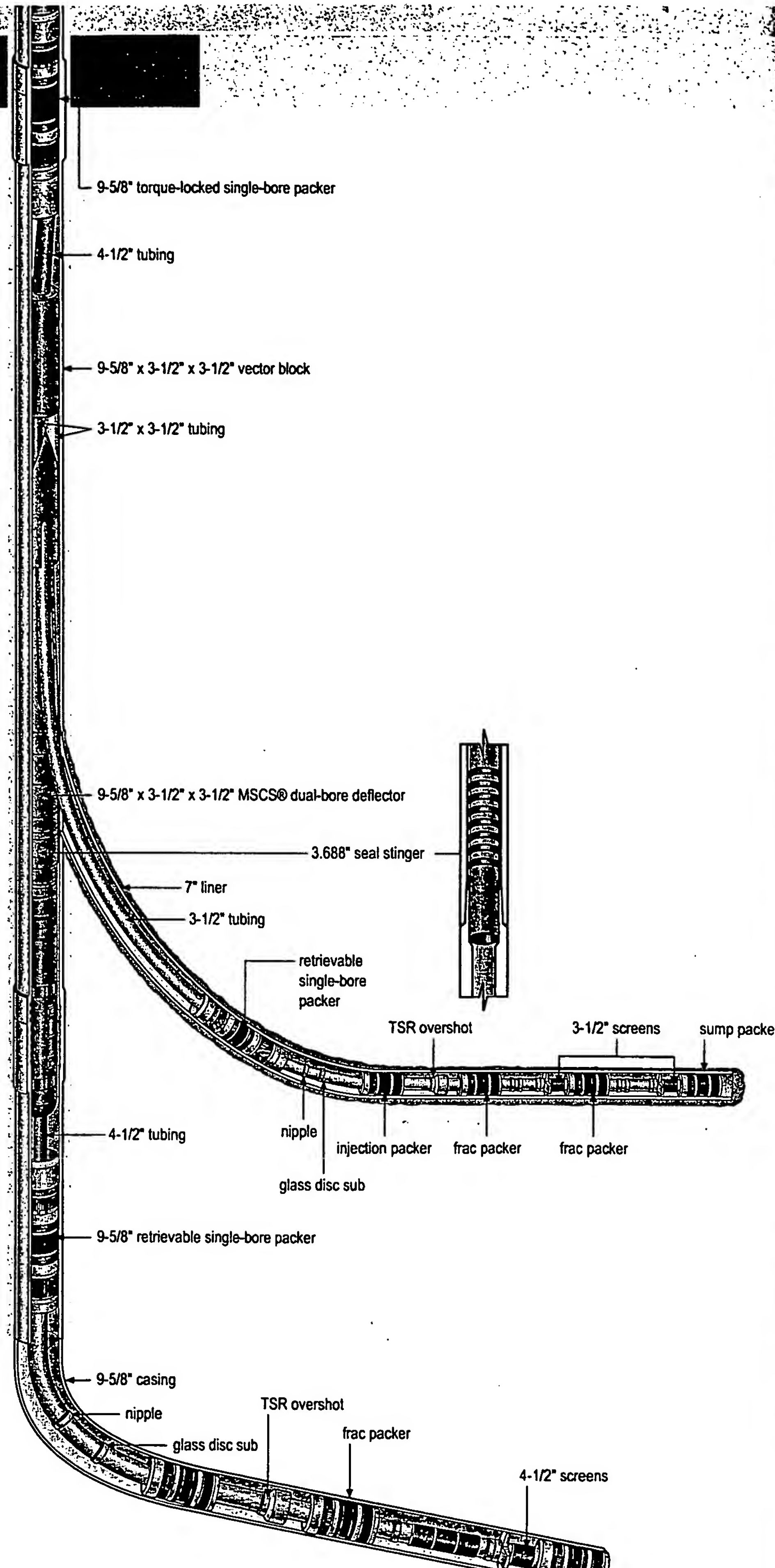
Sperry-Sun's RMLS™ system was used to provide maximum reservoir exposure. Two 9-5/8" RMLS™ pre-milled casing joints were installed in the shale. The system allowed two 8-1/2" horizontal laterals to be drilled into the reservoir. The open hole was then lined and cemented with a 7" x 4-1/2" liner. The laterals were then perforated underbalanced and isolated prior to completion of the other junctions. A third lateral was drilled out of the lower mainbore shoe of the 9-5/8" joint because the RMLS™ system does not restrict the ID of the mainbore casing. The MSCS® system was installed in the lower lateral to provide re-entry and zonal isolation to the first and second laterals. All three laterals were produced through dual strings, which provide the flexibility of commingled and/or isolated production.

South America Offshore Brazil (Subsea)

RMLS™ and MSCS® with Vector Block Multilateral Project

A multilateral injection well was completed offshore Brazil. The customer planned to drill a 12-1/4" mainbore and an 8-1/2" lateral bore and desired the ability to inject into the two main zones simultaneously from a single tubing string. This well is located in 800 meters of water and was drilled to a measured depth of 2,500 meters. A 9-5/8" RMLS™ system and a 9-5/8" MSCS® system with vector block were installed to meet the customer's particular application requirements. These systems provide a selective level 5 junction with pressure integrity at the junction and full access to both zones. The vector block component of the MSCS® system allows independent intervention, isolation, and flow control to either the lateral or mainbore.

Because this was the first deepwater installation of the RMLS™ and MSCS® systems from a floater, innovative new technology was developed to deal with the specialized application. The completion had to allow for the lateral and mainbore to be both fractured and completed with a gravel pack. Introduced was the 9-5/8" pre-milled high-pressure window system, designed to have a rating of 10,000 psi pressure; the "cut-on-depth-tool," which allows the lateral liner to be cut at a specific place prior to washover operations from a floater; and the "junction isolation tool," which isolates the junction from being affected by fracturing and reversing pressures during the mainbore frac operation.

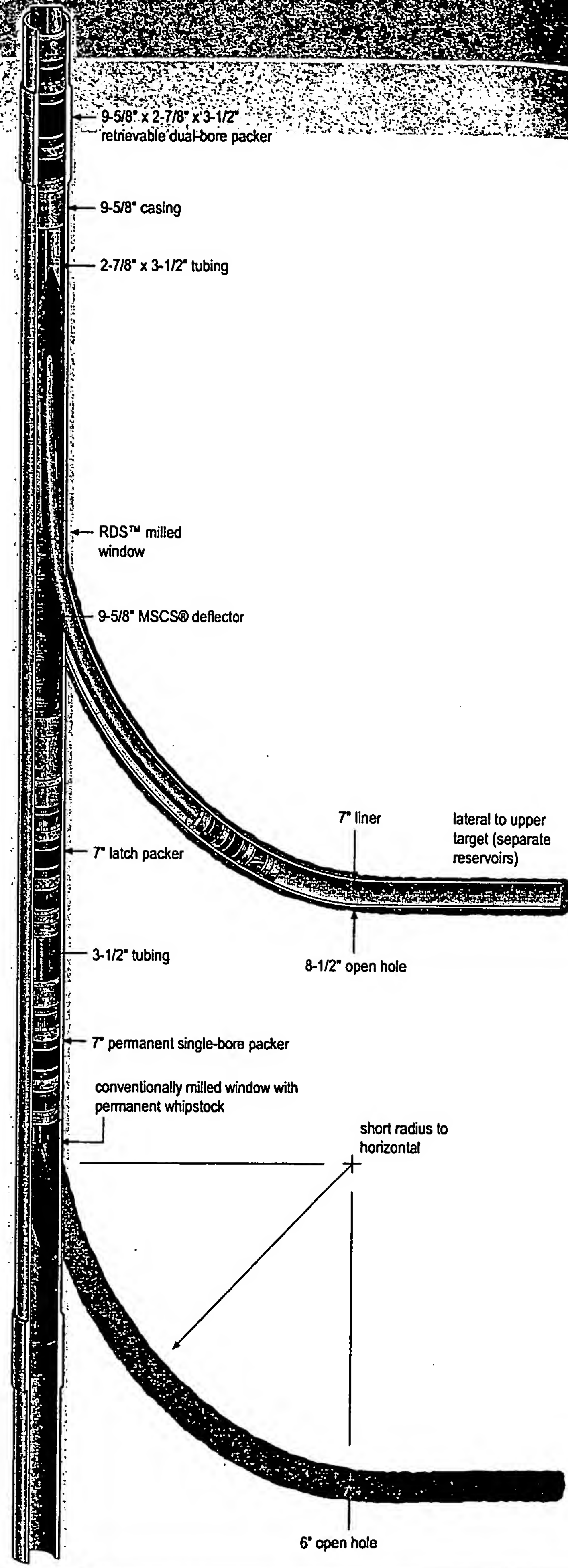


Middle East Offshore Abu Dhabi RDS™/RMLS™ and MSCS® Multilateral Project

An RDS™ system was used in the Middle East to re-enter 9-5/8" casing and install an MSCS® system. The Abu Dhabi offshore well was drilled in 1991 as a deviated dual producer. High water content was encountered early on from the upper reservoir, resulting in the abandonment of this zone. In order to re-establish oil production from the upper reservoir and increase production from the lower reservoir, the operator re-entered the well and drilled a lateral section in each reservoir layer.

The operator took the opportunity to use the latest in milling technology—the RDS™ system—to mill a window in the 9-5/8" casing. The lateral was then lined and cemented with a 7" liner that included a 7" high-torque RMLS™ window joint. The 7" RMLS™ window joint will enable a secondary lateral to be drilled from the primary lateral in the future. An MSCS® completion system was used to complete the well as a dual producer. This combination of the multilateral systems resulted in the following:

- Water-free re-establishment of production in the upper reservoir
- Capability to produce to re-enter for logging and stimulation and to monitor each reservoir layer selectively through the final dual completion
- Provision for flow control of each lateral if required in the future
- Conservation of platform slots by the use of an existing wellbore



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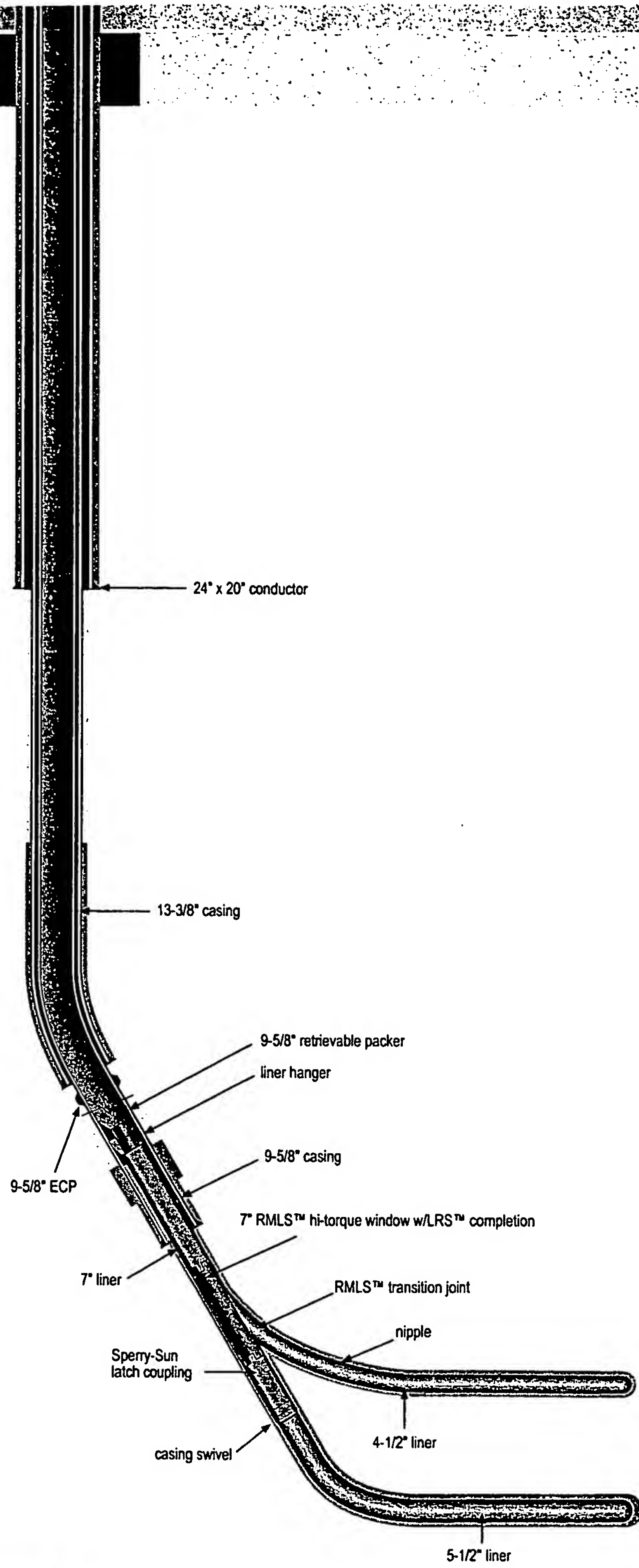
Europe Offshore Norway
RMLS™ and LRS™ Multilateral Project

Three multilateral wells have been drilled in the chalk fields in the Norwegian sector of the North Sea. All three presented technical and economic challenges, but continuous improvements resulted in both economic and technical successes.

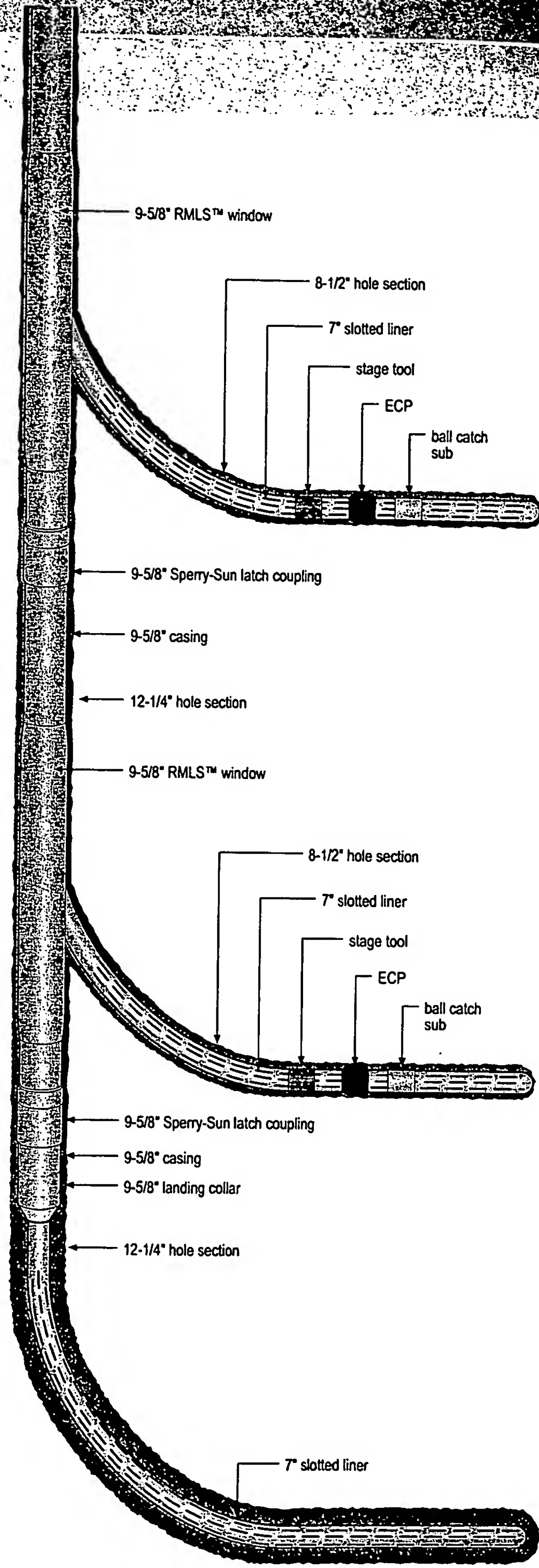
The last well was the most technically complex of the three and had 7" RMLS™ and 7" LRS™ systems installed. The well required the development of high-pressure through-tubing stimulation for both the main and lateral bores to produce two separate layers of the reservoir.

Experience gained from the two previous multilateral installations was put to use, and the third installation was completed ahead of schedule and under budget. The production results were consistent with the previous multilateral installations, with the additional lateral section showing increasing oil production compared with a standard horizontal well. The LRS™ system will enable selective reentry, isolation and future stimulation of either the main or the lateral bore.



South America Onshore Venezuela RMLS™ Heavy-Oil Multilateral Project

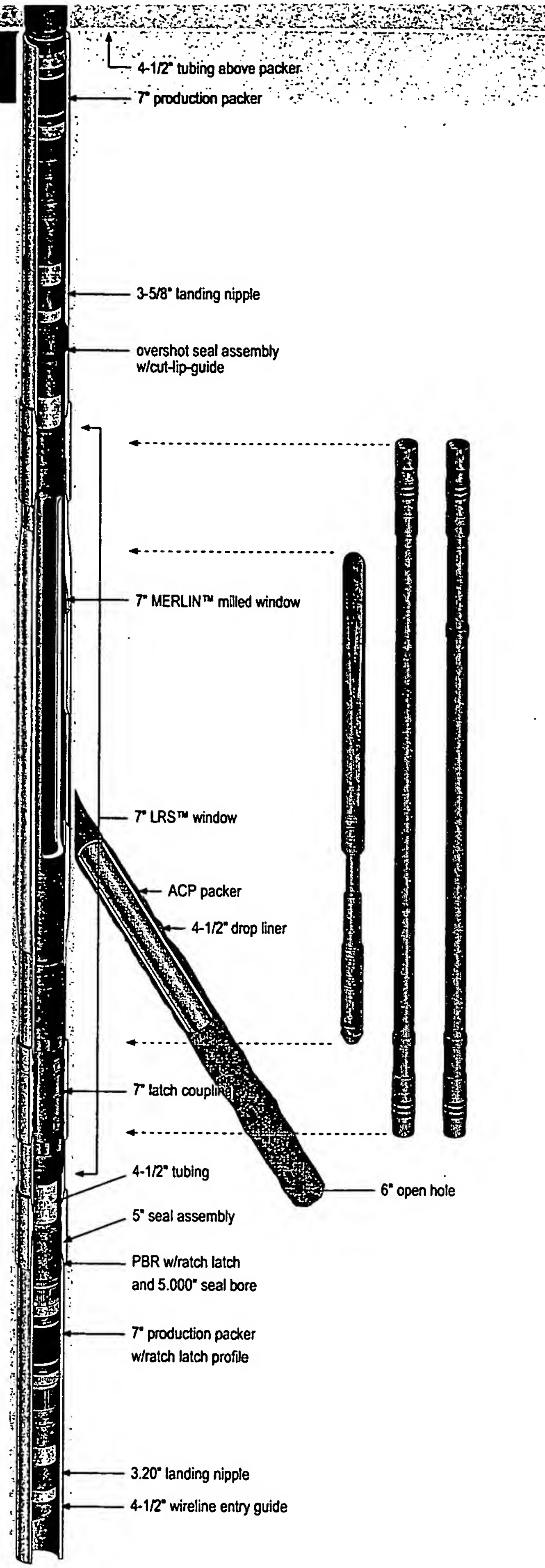
A customer in Venezuela has used multilateral technology to increase the amount of reservoir exposure in the heavy-oil fields in the Orinoco region. Using Sperry-Sun's RMLS™ system, the customer has placed up to two additional wellbores into the reservoir from a single surface location. Two 9-5/8" RMLS™ windows were installed in the mainbore at around 80 degrees inclination. Long lateral legs were drilled from each window, and a third lateral was drilled out the shoe of the lower mainbore. The laterals had 7" slotted liner installed with liner lengths up to 6,000 feet long. The top of the lateral liner is stage cemented and then washed over, which provides sand control at the RMLS™ junction. Once installed, the RMLS™ junction does not restrict access to the lower mainbore and allows a progressive cavity pump to be placed below the lower window junction. The placement of the pump below the lower window means the customer can take full advantage of the gravity feed drainage from the upper two laterals while still being able to draw from the lateral coming out the bottom of the mainbore.



AGIP Onshore Italy
MERLIN™ and LRS™ Multilateral Project

AGIP has used multilateral technology to reduce the overall capital expenditure of drilling in the Val Di Agri oilfield in Italy. Highly compressive limestone formations can cause drilling times of several months to reach the reservoir top. Reducing the number of surface wellhead sites in a national park is an environmental and financial incentive. Multilateral technology will be used to increase the drainage from the fractured zones around the primary target. The more fractured zones intersected in the reservoir, the more likely that the production will improve.

A 7" MERLIN™ system was used to mill a window and create a multilateral junction. Developed with Smith International, the MERLIN™ system can create a level 2, 3, 4, or 5 well if an MSCS® system is also installed. The 7" LRS™ completion system will allow through-tubing re-entry, flow control, and zonal isolation on coiled tubing or wireline. Sperry-Sun latch couplings were installed to allow full-gauge access to the lower mainbore until the lateral was drilled. Using the Sperry-Sun latch coupling eliminates the need for costly anchor packers and gives a positive depth and fixed orientation to the lateral hole. AGIP installed two or three latch couplings per well with the intention of using one or two with the third for future opportunities. The LRS™ window is run with a TPI™ sleeve installed to maintain pressure integrity in the string, which is removed later through tubing. A TEW™ whipstock allows the lateral to be accessed at any time using coiled tubing or wireline.



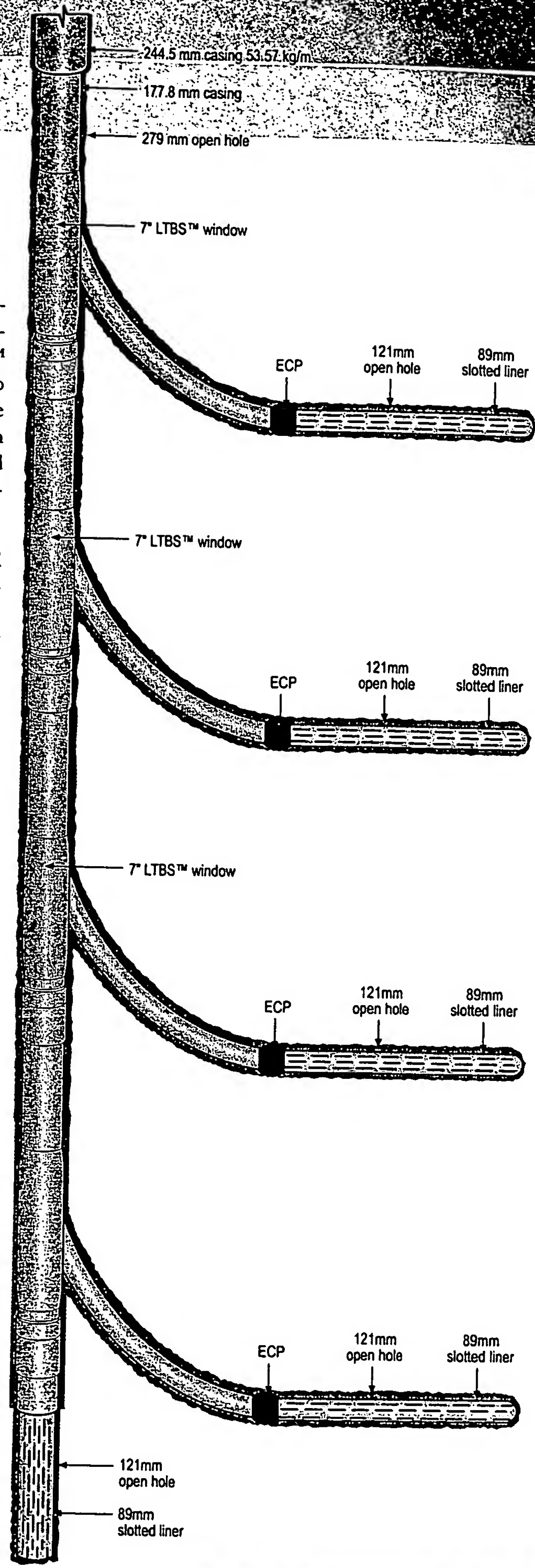
North America Onshore Canada LTBS™ Heavy-Oil Multilateral Project

A customer in Canada has made use of multilateral technology to maximize the amount of reservoir exposure in their horizontal wells. The LTBS™ system has been used in Canada to achieve up to 2,800 meters of reservoir exposure from a single well. These wells include several lateral bores, which are tied back to the larger mainbore. The splayed leg well configuration allows for the maximum reservoir drainage from a single horizontal mainbore.

The LTBS™ system was the first multilateral technology developed by Sperry-Sun in joint cooperation with a customer. In 1997 the first five-leg, level 3 multilateral LTBS™ well was successfully drilled and completed in a thin (5 meters), shallow (409 meters), unconsolidated sandstone formation near Brintnell, Alberta. It contains 14-degree API crude oil with only a 5 percent primary recovery, and the reservoir has established a definite correlation between horizontal reservoir exposure and increased production.

The mainbore of the well was drilled horizontally and cased with 178-mm liner, including four LTBS™ windows that were oriented and set to drill out in the same parallel southerly direction. The laterals were individually spaced out by 200 to 300 meters. Each of the laterals and the mainbore was completed with 89-mm slotted liners, and the junctions were protected by the level 3 LTBS™ system. This system uses a gate that closes around the top of the lateral liner, which gives mechanical integrity between the mainbore casing and the lateral liner and controls sand production.

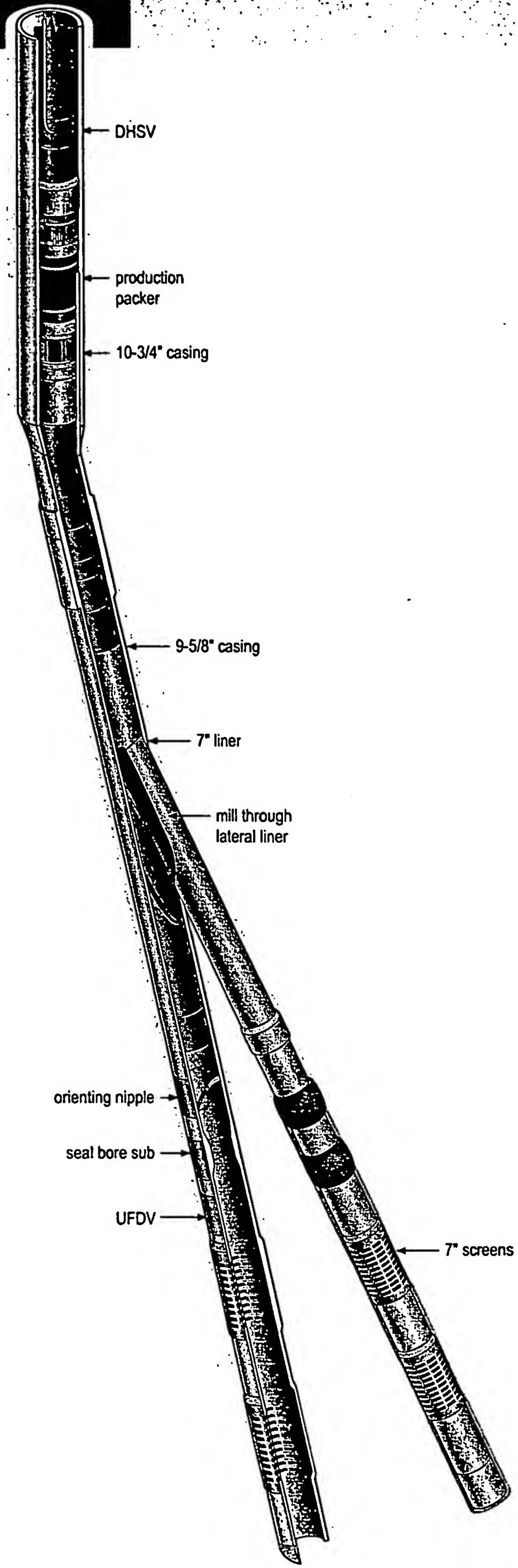
The favorable production of this LTBS™ installation for the customer resulted in continued multilateral development in this field. A total of 15 LTBS™ systems have been installed in western Canada, and more than 50 systems have been sold globally.



Norsk Hydro Offshore Norway 4503™ Multilateral Project

Norsk Hydro has used multilateral technology to increase reservoir drainage on the Troll Olje field offshore Norway. The first 4503™ project was carried out in well 31/5-H-3 in 1997. This was the first successful cased hole multilateral well from a floating rig. The well was completed without any major problems and is producing from both laterals. In 2000, two more 4503™ system wells were completed on Troll Olje (K-14 and J-21), and a third well is being planned.

In all three wells the 4503™ multilateral system was run horizontally in 9-5/8" casing with 7" mainbore screens below. A releasable no-go tool was used to locate a 9-5/8" no-go nipple for depth reference. Upon completion of the 9-5/8" window milling operations, a formation consolidation treatment was performed by injection of resin into the formation in order to prevent subsequent sand production. The 7" lateral screen liner was installed, and two ECPs were placed above the screen section. The junction was cemented with M-SEAL™ cement through an inner string, and a stage cement collar was placed above the ECPs. Screen installation, ECP inflation, and junction cementing were performed in one run. To re-establish the mainbore, a mill guide was first installed at a controlled position relative to the hollow whipstock. A pilot hole was then milled through 7" liner and the hollow whipstock. Upon retrieval of the mill guide, the pilot hole was enlarged to 6-1/8". Milling operations were performed by milling partner Weatherford. The subsea downhole motion compensator was used on critical operations. This tool landed in the wellhead. As weight was applied on the compensator, it started to feed pipe at controlled rates, i.e., it removed the rig heave from the milling operations. The well was then completed. The wells have been drilled and completed as follows: first well in 96 days total, of which 38.2 were spent on the lateral; second well in 64.6 days total, of which 26.3 days were spent on the lateral; third well in 71 days total, of which 25.3 days were spent on the lateral. The horizontal reservoir sections of the three wells have become longer, with a total length of 3,716 meters, 4,332 meters, and 6,071 meters, respectively.



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Global Multilateral Centre

Sperry-Sun Drilling Services
1400-5th Street
Nisku, Alberta T9E 7R6 Canada
Telephone: 780-955-7606
Fax: 780-955-2332

Asia Pacific

Sperry-Sun Drilling Services
11th Floor, Menara Tan & Tan,
207 Jalan Tun Razak,
50400 Kuala Lumpur, Malaysia
Telephone: 603-2163-4567
Fax: 603-2161-5787

Europe and Africa

Sperry-Sun (UK) Limited
Howe Moss Drive
Kirkhill Industrial Estate
Dyce, Aberdeen, AB21 0GL
Scotland United Kingdom
Telephone: 44-1-224-727200
Fax: 44-1-224-773381

Sperry-Sun Drilling Services
Plot 158, Trans Amadi Industrial Layout
P.O. Box 462
Port Harcourt
River States, Federal Republic of Nigeria
Telephone: U.S. Satellite 001-817-493-5540
Telephone: Nigeria Telecom 234-84-231-147
Fax: U.S. Satellite 001-817-493-5541
Fax: Nigeria Telecom 234-84-239-223

Middle East

Sperry-Sun
Building 9 Jebel Ali Free Zone
c/o Oilfield Supply Centre
P.O. Box 3101
Dubai, United Arab Emirates
Telephone: 971-4-883-461
Fax: 971-4-836-463

North America

Sperry-Sun Drilling Services
110 Capital Drive, Suite 200
Lafayette, Louisiana 70508 USA
Telephone: 337-232-7831
Fax: 337-232-4792

Sperry-Sun Drilling Services
1400-5th Street
Nisku, Alberta T9E 7R6 Canada
Telephone: 780-955-7606
Fax: 780-955-2332

Sperry-Sun Drilling Services
3000 North Sam Houston Parkway East
Houston, Texas 77032 USA
Telephone: 281-871-5100
Fax: 281-871-4269

South America

Sperry-Sun Drilling Services
Carrera 9 No 76-49 Piso 5
Bogota, Colombia
Telephone: 57-88-758366
Fax: 57-88-753766

Websites: www.sperry-sun.com
www.halliburton.com

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